NASA-CR-197188

NASw-4435



# Final Detail Design Report

S94-01-301-1B
May 3, 1994

## Triton II (1B)

AE421-01-Team Alpha

Lead Engineer: Chris W. Giggey
Team Members:
Michelle L. Clark, A.G. Meiss
Jason R. Neher, Rich H. Rudolph

Submitted to:
Dr. J.G. Ladesic

(NASA-CR-197188) TRITON 2 (1B) (Embry-Riddle Aeronautical Univ.) 94 p

N95-12636

Unclas

G3/05 0026164

# Table of Contents

## List of Figures

## List of Tables

# 1. Project Summary

## 1.1 Design Goals

The goal of this project was to perform a detailed design analysis on a conceptually designed preliminary flight trainer. The Triton II (1B) must meet the current regulations in FAR Part 23. The detailed design process included the tasks of sizing load carrying members, pulleys, bolts, rivets and fuselage skin for the safety cage, empennage, and control systems. In addition to the regulations in FAR Part 23, the detail design had to meet established minimums for environmental operating conditions and material corrosion resistance.

## 1.2 Minimum Environmental Operating Conditions

The detail design must meet the nine minimum environmental operating condition. The aircraft must be able to operate at temperatures between -40°F and +122°F without degradation. The Triton must be able to operate at altitudes up to 14,000 feet. A minimum sand and dust requirement states that all external surfaces and working mechanisms must be able to endure particles up to 150 microns in size. The quantity that must be withstood is up to 0.041 grams per cubic foot. All external surfaces and mechanisms must be sealed against water intrusion from rainfall at a rate of up to 4.0 inches per hour with net wind velocity of up to 150 miles per hour. The statement of work also states that all external surfaces and mechanisms must endure 100 percent humidity at +95°F without deterioration. Further, the aircraft must be able to withstand ice at temperatures -40°F and remain operational. The aircraft structure must be able to support an accumulation of 10.0 inches of wet snow. All of the aircraft's external surfaces and mechanisms must be able to endure long periods of exposure to salt or fog as would be encountered in coastal regions. Further, the parts must withstand corrosion experienced in these conditions in order to ensure ease of movement. The aircraft must be able to withstand wind gusts in accordance with FAR Part 23. The ground tie downs must be able to withstand loads generated from winds up to 120 mph from any lateral direction and an incident angle within a range of -10 to 10 degrees. Finally, the airplane must be able to endure external shocks and internal vibrations as indicated in FAR Part 23 §23.561 through §23.629.

### 1.3 Purpose of Paper

The purpose of this paper is to illustrate the methods and procedures used to complete the requirements in the statement of work. This document should remain as reference for future modifications to the detail design of the Triton II (1B). Further, this document stands to prove that all the above design requirement have either been meet or exceeded.

### 1.4 Summary of Critical Detail Parts

**Table 1.1: Summary of Critical Detail Parts**

| Part # (dwg. #) | Part Name | Load/Type (psi) | Load Source | M.S./Type | Page Number |
|---|---|---|---|---|---|
| 1(201) | Hat Sections | 3000 | Crash | 1.5/Buckling | 26 |
| 24(402) | Mid-Section Stringer | 17 470 | Cruise Flt. | 0.066/Buckling | 32 |
| 01(301) | Empennage Skin | 1 885 | Cruise Flt. | 0.003/Buckling | 31 |
| 01(402) | Front Push Pull Rod | 3 693 | Man. Flt. | 0.10/Buckling | 35 |
| 05(402) | Actuator Crank | 4 416 | Man Flt. | 0.25/Tear Out | 36 |

## 2. Description of Design

### 2.1 Spatial Requirement and General Configuration

This Spatial Requirements Specification applies to a high wing, 2-place staggered seat, front engine, tractor aircraft. The power plant consists of a 165.2 lb. Duncan SR-120R rotary engine. The cockpit contains two Jungle Aviation And Radio Service (JAARS) seats that are arranged in a staggered setup. In order to satisfy crash worthiness requirements, these seats are mounted to the safety cage in a manner consistent with FAR Part 23 and the JAARS documentation. This aircraft has conventional rudder and brake controls along with a tricycle landing gear configuration. The landing gear is mounted to a stiffened section of the safety cage. The actual mounting will take place on the exterior of the aircraft. Side stick controls are used instead of the conventional yoke controls. These where found in order for future upgrades to fly by wire, where joysticks would be common place in the cockpit. The handles for the side stick controls are placed on each side of the cabin angled at forty-five degrees. This angle was chosen for pilot comfort and rotational clearance. Due to the staggered seating conditions, the instrument panel is split into three sections. The first section is located in front of the student pilot and it contains all instruments needed for instrument flight. The second section is the mid-section, which falls between the student pilot and the instructor pilot. This particular section, due to the staggered seating arrangement, is angled at twenty-five degrees incident to the windshield. This section contains all of the aircraft's radios. The third section is directly in front of the instructor pilot. This section is flat as was the first. This section contains all of the fuses, cabin heating controls and air controls.

The passengers are protected by an occupant safety cage as part of the fuselage, an innovation inspired by technologies used in present day race cars. The safety cage maintains a volume of space around the occupants in the event of a crash. It is hoped that the cage and JAARS seats will significantly reduce the likelihood of serious injuries. Most importantly, the head is kept completely clear of any cabin components. The exterior walls of the aircraft are two inches thick in order to enclose the cage. The safety cage will be constructed from 7075-T6 aluminum, and the skin will be constructed from 0.032", 2024-T3 aluminum. The members of the cage have a square hat shaped cross section. The hollow space will be filled with a lightweight polyurethane filler. The safety cage is enclosed within a maximum cabin width of 40.0 inches and a maximum cabin height of 53.8 inches. A section of the cage is stiffened with three gussets in order to support the landing gear.

The attached drawings (See Drawing S94-1A-102-1B) show in graphic detail the spatial requirements. These spaces must be maintained through the detailed design process. If these dimensions are maintained the occupant safety requirements set forth by the FAA in FAR Part 23 will be satisfied.

## 2.2 Fuselage and Safety Cage Design

The idea of the safety cage stems from the current usage of roll cages used in the racing industry. The main idea of the safety cage is to insure that the occupants are able to survive a severe crash. This would be accomplished by allowing the safety cage to breakaway from the aircraft during a crash. The idea of this breaking away was based on the fact that the loss of mass will result in a loss of energy. This can be seen in formula one class cars when they impact a wall. In the design process, the safety cage went through many changes. In the beginning it was conceptualized that the cage would be constructed out of tubular sections. Since this was the most common fabrication of existing cages, it only seemed practical to copy this process. Later studies however, proved that it would be difficult to attach anything to the tubes without the use of special fasteners. In order to attach skin, seats, wing interface, ect. a flat surface must be provided. This lead to the idea of using a hat channel. The only drawback to the use of a hat channel is corrosion. When the skin is fastened to the channel it is impossible to check for corrosion. To account for this, a double layer of sealant will be used. Further, a polyurethane insert will be placed in the hat channel. This insert would increase the stiffness of the hat channel while absorbing vibration and noise.

After the geometry of the safety cage was decided on, the design team had to decide how to join them. In the beginning it was felt that the members would be welded together. This seemed to be the best solution except two difficulties in fabrication appeared. First, it did not seem practical for workers to weld complex joints for every aircraft. Second, since thin sheets of aluminum will be used it would be impossible to create a perfect weld to hold the cage together during a crash. To overcome this, a new idea of preformed joints was used. This idea was found in an article about pre-formed structural components used in car chassis. The process used to make the joints for the safety cage will be investment casting. Although this requires a higher tooling cost, this is offset by the ability to make copies of the joints at a high rate.

Since the safety cage was the primary structure of the fuselage special attention was given to the wing interface. According with the meeting held with the wing design group it was decided that the wing attachment points would be located at 25% and 70% of the root chord. To accommodate the connection of the wing, square tubes will be used along the top of the cage. This configuration lead to any number of wing attachment possibilities.

In order to use a door to enter the aircraft, a member of the safety cage had to be removed. To allow for this structural discontinuity, a latching mechanism was created. Using an idea from the automotive industry a door member is allowed to be latched at the free ends of the beam. In the latched position, the two ends of the member are firmly secured. This is accomplish by placing a hinge at the rotation end and a dead bolt at the latching end. What this creates is a simple beam attached at the ends. In this configuration the door member will transmit axial loads though the frame, while still absorbing side impacts.

## 2.3 Mid-Section and Empennage Design

The mid-section and empennage were inspired by the original detail design of the Triton. The modifications to the preliminary design, resulted in two significant changes. First, the empennage of the original Triton was broken up into two distinct parts. These parts are called the mid-section and the empennage (See Drawing S94-1A-301-1B, Sheet 1). This separation was motivated by a drastic change in exterior geometry. Second, the preliminary designers placed the front and rear spares of the horizontal tail (h-tail) and vertical tail (v-tail) at the same location. Thus, the old interfaces for the h-tail and v-tail had to be combined into one interface(See Drawing S94-1A-301-1B, Sheet 3 ).

The empennage is constructed from four stringers, six formers, skin, and several connectors. The first stringer is placed 45 degrees from the vertical, then all the other stringers a separated by 90 degrees. The formers vary in size and function, but all are in the shape of an oval. The skin is flat rapped and connected to the stringers and formers using rivets. The h-tail and v-tail are bolted to interfaces on two of the formers. The empennage is bolted to the mid-section using bolts, nuts, and washers (See Drawing S94-1A-301-1B, Sheet 1 through 5).

The mid-section is constructed from four stringers, two formers, skin, and several connectors. The first stringer is placed 45 degrees from the vertical, then all the other stringers a separated by 90 degrees. The formers vary is size, shape and function. The skin is flat rapped and connected to the stringers and formers using rivets. The mid-section is bolted to the fuselage using bolts, nuts, and washers (See Drawing S94-1A-301-1B, Sheet 1 through 5).

The mid-section and empennage were designed to satisfy all the requirements of the statement of work. These requirements were fulfilled as follows:

1. These parts were designed to withstand the load requirements stated in FAR Part 23, Appendix A.
2. The temperature was found to have no effect on the structural integrity.
3. The atmospheric pressure was found to have no effect on the structural integrity.
5. The seems between sections of the skin were sealed to prevent all water intrusion.
6. The skin of the aircraft is painted with standard aircraft paint to prevent corrosion or wearing from contact with dust, sand, rain, salt, fog, snow, ice, and humidity.

7. These sections have been found to be capable of supporting ten inches of wet snow without structural failure.
8. These sections have been found to be capable of resisting a 120 mph lifting force on the tie down bolt.
9. These sections meet or exceed all minimum safe life requirements.

As can be seen by the above list, all the requirements of the statement of work have been fulfilled for the mid-section and empennage.

**2.4 Aileron Design**

The design for the ailerons was inspired by looking at the control systems of a Cessna 172. The main difference was the result of staggered seating. The staggered seating presented a problem in connecting the dual controls. A closed system was used to solve this problem. This allows the dual controls to be connected with one cable instead of the usual two. In a closed system the cable is always in tension. The deflection of the ailerons is caused by the rotational motion of the stick. A square collar and a square tube are used to capture this motion. The square collar has bearings at diagonal corners to allow the square tube to pass through by linear motion but translate the motion for rotational motion. To keep the square tube in place there is a stop on either side of the collar. The stop is a formed piece of Aluminum that serves the dual purpose of keeping the collar in place and supporting the stick assembly in the vertical direction, (see drawing S94-1A-401-1B). The stick rotates forty-five degrees to the left and forty-five degrees to the right. This rotation satisfies the minimum aileron deflection requirements of ten degrees up and down.

**2.5 Elevator Design**

The side stick control used in this design was based on advancing technologies. These technologies are making the large yoke obsolete. The dual controls for the elevator are connected using a circular tube that crosses behind the dash. The two sticks are connected to a cross tube. The cross tube connector is slotted in order to allow pure linear motion.(See drawing S94-1A-401-1B) This connection will allow a traveling motion of 6 inches, 3 inches forward and 3 inches backward. Connecting the cables at the lower end of the cross tube will allow the elevator to be deflected $10^{o}$ upward and downward. The cables are strung along the underside of the floor and along the skin of the empennage (See Drawing S94-1A-401-1B). To connect the cables to the elevators, a bell crank attachment is used. This attachment is manufactured by allowing a rod to connect the two elevators at 25% of the chord. A bell crank will be welding in the middle of the rod allowing the cables to be attached (See Drawing S94-1A-401-1B).

### 2.6 Rudder Control System Design

The rudder control system includes a deflection of +/- 21° for both the rudder and the nose wheel. Also included in this section is the differential braking system. The differential braking system includes a separate master cylinder, parking brake, valves and is visually displayed in the appendix section. The rudder system is controlled by the pilot's or instructor's feet through two sets of bottom pivoting rudder pedals. The rudder pedals are connected to a series of push-pull rods, bell cranks, and pulley wires. The major obstacle was to account for the spacing required for the crank-rod interface to operate properly. This was solved by placing ball bearings between two crank plates that have the rod end connectors already attached.

### 2.7 Dashboard Configuration and Design

The dashboard provides space for both VFR and IFR instruments as well as all fuses and control knobs (see Drawing S94-1A-501-1B). The dashboard will be riveted to the skin of the Triton using L brackets on both sides. Sun glare will be reduced by a two inch sun visor on the top section of the dashboard. All instruments will be mounted to the dashboard which will then be covered with a heat treated vinyl cover for improved looks. Both the heating system and the air-conditioning unit will be attached to the firewall with air vents leading from the air inlets into the cabin. A list of all the proposed instruments included within the dashboard can also be found on Drawing S94-1B-501-1B. The components with stock numbers were obtain from Aircraft Spruce & Specialty Company catalog.

## 3. Loads and Loading

The loading and design criteria are specified in the Statement of Work documentation. This document requires that the aircraft be designed for the loading conditions stated in FAR Part 23. In addition, the aircraft must be designed to withstand snow loads and tie-down loads.

## 3.1 Loads on the Safety Cage

The limiting restriction set forth by the FAR Part 23 requires that each part be able to sustain a 9g load forward, 3g load upward and 1.5g load sideways. To satisfy this requirement each part of the cage was sized according to the loadings present.

### 3.1.1 Forward Loading on the Safety Cage

The first loading condition was the forward 9g load. This condition represents a forward nose-in crash. The main carrying members where the four floor supports, the two lower side supports and the two windshield supports. Using the total aircraft weight of 2000 lb., each member would be carrying approximately 2250 lb. during the 9g crash (See Figure 3.1).

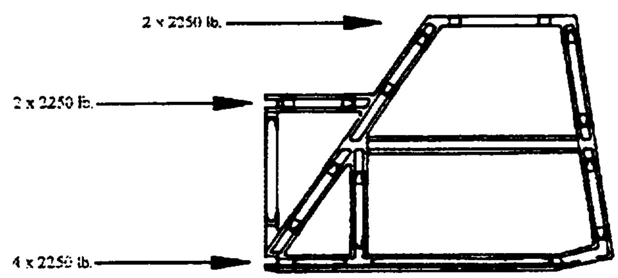



**Figure 3.1: The Forward Loading Conditions on the Safety Cage.**

### 3.1.2 Side Loading on the Safety Cage

The second loading condition dealt with a side crash. Under this condition, all the side members carry equal loads. This would represent a crash with the cockpit rolling over on its side. Using the aircraft weight of 2000 lb., each member would carry 600 lb. (See Figure 3.2).

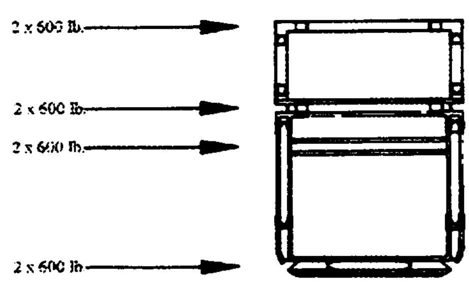



**Figure 3.2: The Side Loading Conditions on the Safety Cage.**

### 3.1.3 Upward Loading on the Safety Cage

The third load condition represents a crash where the plane lands on the underside of the fuselage. The members chosen to carry the load where the four supports connecting the two side floor members to the two side members. Each of the four supports would carry about 1500 lb. each using the aircraft weight of 2000 LB (See Figure 3.3).

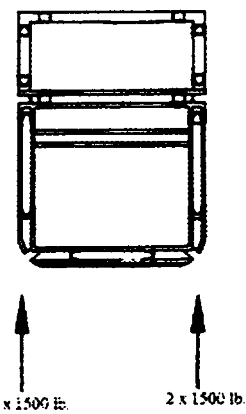



**Figure 3.3: The Upward Loading Conditions on the Safety Cage.**

### 3.1.4 Downward Loading on the Safety Cage

The forth loading condition represents the fuselage landing on its roof. For this loading condition the four cage supports carry the load, each load was calculated to be 1500 LB (See Figure 3.4)

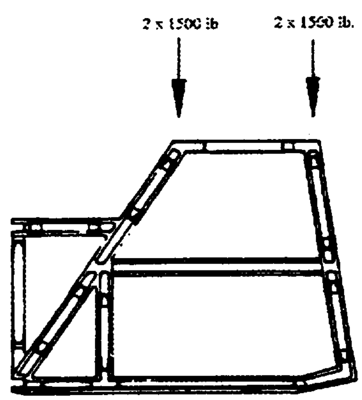



**Figure 3.4: The Downward Loading Conditions on the Safety Cage.**

### 3.1.5 Lift Loading on the Safety Cage

The fifth loading case dealt with an aircraft flying in the utility category. Under this condition the four cage supports would carry the loads. From the calculations each of the front supports would carry 3360 lb. while the each rear member would carry 1460 lb. (See Figure 3.5).

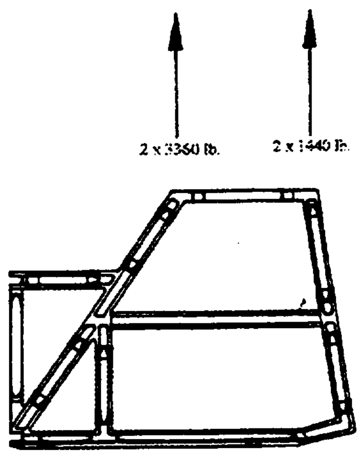



**Figure 3.5: The Lift Loading Conditions on the Safety Cage.**

### 3.1.6 Worst Case Forward Loading on the Safety Cage

Loading case six was the worst case, therefore, it was used for sizing. This case dealt with a crash where the six lower floor members carried all the loads. This would represent a crash where the lower portion of the fuselage impacted the ground. From calculations, it was determined each member would have to carry 3000 lb. (See Figure 3.6).

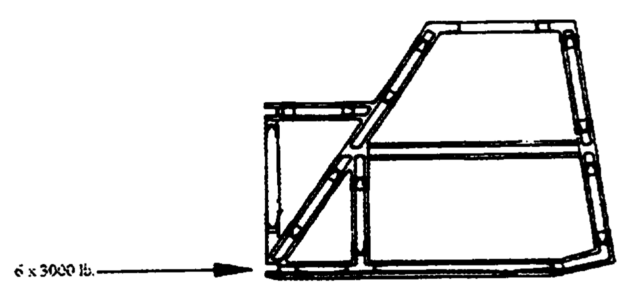



**Figure 3.6: The Worst Case Forward Loading Conditions on the Safety Cage.**

## 3.2 Horizontal Tail and Vertical Tail Loads

In FAR Part 23 appendix A, two methods of calculating the design loads for the horizontal tail and vertical tail are given. The first method is for the maneuvering case, and the second method is for the level cruise case. Minimum design loads for the tail cone will be based on the worst case scenario generated from the calculations to follow.

### 3.2.1 Maneuvering Case

The method for calculating maneuvering loads was modified slightly. The flat section of the loading quadrangle represents the load contribution from the hinge gap. This flat section will be ignored because the width of this gap is unknown. The sides of the shape will simply be extended to form a triangle (See Figure 3.7). This is a conservative simplification because it places the force further back.

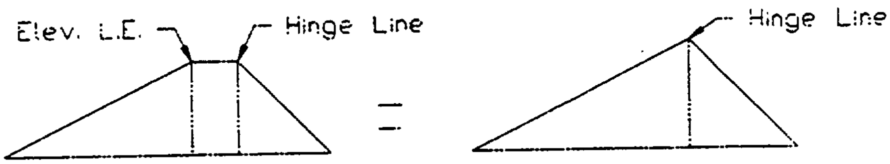



**Figure 3.7: Simplification of Maneuvering Load (Chordwise)**

### 3.2.2 Average Surface Loading on the Horizontal Tail

To find the chordwise load distribution, the average surface loading ($\overline{w}$) was found using an equation in FAR Part 23, Figure A5. The equation for the Horizontal Tail was:

$$\overline{w} = 4.8 + .534(n_1 \frac{W}{S}) = .260 \, {}^{lb}\!/_{in^2}$$

Where: $n_1 = 4.4$ (Limit load factor for utility category aircraft)

$\frac{W}{S} = 13.91 \, {}^{lb}\!/_{ft^2}$ (Wing Loading for the Triton II)

### 3.2.3 Loading on the Horizontal Stabilizer

The chordwise load distribution on the horizontal stabilizer was simplified by finding the resultant and its location. The resultant loading distribution was found to be 1.52 lb./in at a distance of 7.78 in. from the leading edge. These were found by calculating the area under the chordwise distribution curve (See Figure 3.8).

$F_{cH.S.} = .5\overline{w}\,c_{H.S.} = 1.52 \, {}^{lb}\!/_{in}$ (Resultant of the Chordwise Distribution on the Horiz. Stab.)

Where: $\overline{w} = .260 \, {}^{lb}\!/_{in^2}$ (Average Surface Loading on the Horizontal Tail)

$c_{H.S.} = 11.66 in$ (Chord of the Horizontal Stabilizer)

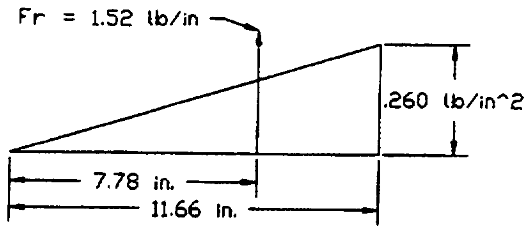



**Figure 3.8: Calculation of Chordwise Resultant for the Horizontal Stabilizer**

The spanwise load distribution on the horizontal stabilizer was simplified by finding the resultant and its location. The resultant load for the horizontal stabilizer was found to be 92.2 lb. at a distance of 30.3 inches from the tip. These were found by calculating the area under the spanwise distribution curve (See Figure 3.9).

$F_{s.H.S.} = F_{c.H.S.} b_{H.S.} = 92.2 lb.$ (Resultant of the Spanwise Distribution of the Horiz. Stab.)

where: $F_{c.H.S.} = 1.52 \, {}^{lb}/_{in}$ (Chordwise Resultant for the Horizontal Stabilizer)

$b_{H.S.} = 60.6 in.$ (Span of the Horizontal Stabilizer)

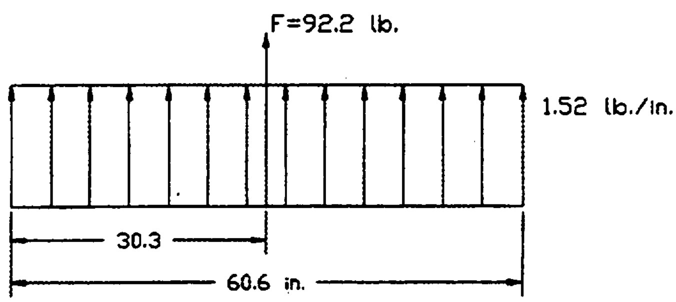



**Figure 3.9: Calculation of Spanwise Resultant for the Horizontal Stabilizer**

### 3.2.4 Loading on the Elevator Due to Deflection.

The chordwise load distribution on the elevator was simplified by finding the resultant and its location. The resultant load distributions were found to be 3.17 lb./in (Root) and .69 lb./in (Tip) at distances of 8.13 in (Root) and 1.75 in (Tip) from the trailing edge. These were found by calculating the area under the chordwise distribution curve at the tip and the root (See Figure 3.10).

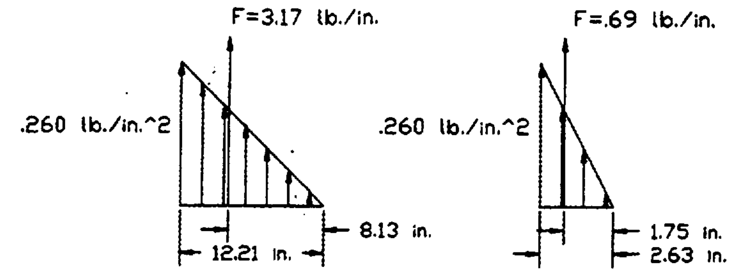
$F_{c.E.R.} = .5 \overline{w} c_{E.R.} = 3.17 \, {}^{lb}/_{in}$ (Resultant Force of Chordwise Distribution at the Root)

$F_{c.E.T.} = .5 \overline{w} c_{E.T.} = 0.69 \, {}^{lb}/_{in}$ (Resultant Force of Chordwise Distribution at the Tip)

Where: $\overline{w} = .260 \, {}^{lb}/_{in^2}$ (Average Surface Loading on the Horizontal Tail)

$c_{E.R.} = 12.21 in$ (Chord of the Elevator at the Root)

$c_{E.T.} = 2.63 in.$ (Chord of the Elevator at the Tip)




**Root** **Tip**

**Figure 3.10: Calculation of Chordwise Resultant for the Elevator at the Root (Left) and the Tip (Right).**

The spanwise load distribution on the elevator was simplified by finding the resultant and its location. The resultant force for the elevator was found to be 100.2 lb. at a distance of 31.5 in from the tip. These were found by calculating the area under the spanwise distribution curve (See Figure 3.11).

$F_{s.E.} = F_{c.E.A.} b_{E.} = 100.2 lb.$ (Resultant of the Spanwise Dist. on the Elevator)

where: $F_{c.E.A.} = \dfrac{F_{c.E.R.} + F_{c.E.T.}}{2} = 1.93 \, {}^{lb}\!/\!_{in}$ (Average Chordwise Resultant for the Elevator)

$b_{E.} = 51.9 in.$ (Span of the Elevator)

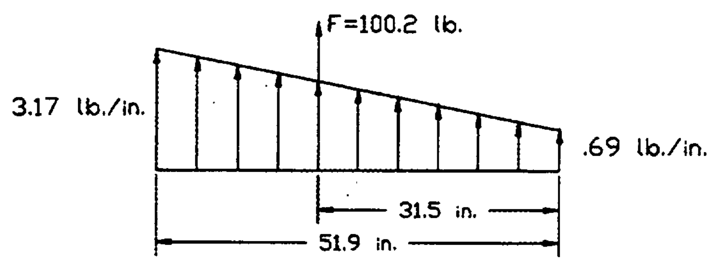



**Figure 3.11: Calculation of Spanwise Resultant for the Elevator.**

### 3.2.5 Load on the Horizontal Tail Due to the Maneuvering Case

The load on the horizontal tail was determined by adding the loads for the horizontal stabilizer and the elevator from the maneuvering case. This resulted in a 192.4 lb. load (See Calculation Below) at a distance of 29.2 inches from the tail cone.

$F_{H.T.M.C.} = F_{s.H.S.} + F_{s.E} = 192.4 lb.$ (Force on Horizontal Tail Due to Maneuvering Case)

where: $F_{s.H.S.} = 92.2 lb.$ (Resultant of the Spanwise Distribution on the Horiz. Stab.)

$F_{s.E.} = 100.2 lb.$ (Resultant of the Spanwise Distribution on the Elevator)

### 3.2.6 Average Surface Loading on the Vertical Tail

To find the chordwise load distribution, the average surface loading ($\overline{w}$) was found using an equation in FAR Part 23, Figure A5. The equation for the Vertical Tail was:

$$\overline{w} = 3.66(n_1 \frac{W}{S})^{\frac{1}{2}} = .199 \, lb/_{in^2}$$

Where: $n_1 = 4.4$ (Limit load factor for utility category aircraft)

$\frac{W}{S} = 13.91 \, lb/_{ft^2}$ (Wing Loading for the Triton II)

### 3.2.7 Loading on the Vertical Stabilizer

The chordwise load distribution on the vertical stabilizer was simplified by finding the resultant and its location. The resultant load distributions were found to be 3.74 lb./in (Root) and 2.25 lb./in (Tip) at distances of 12.53 in (Root) and 7.5 in (Tip) from the leading edge. These were found by calculating the area under the chordwise distribution curve at the root and the tip (See Figure 3.12).

$F_{cV.S.R.} = .5\overline{w}\,c_{V.S.R.} = 3.74 \, lb/_{in}$ (Resultant Force of Chordwise Distribution at the Root)

$F_{cV.S.T.} = .5\overline{w}\,c_{V.S.T.} = 2.25 \, lb/_{in}$ (Resultant Force of Chordwise Distribution at the Tip)

Where: $\overline{w} = .199 \, lb/_{in^2}$ (Average Surface Loading on the Vertical Tail)

$c_{V.S.R.} = 18.8 \, in$ (Chord of the Vertical Stabilizer at the Root)

$c_{V.S.R.} = 11.3 \, in.$ (Chord of the Vertical Stabilizer at the Tip)

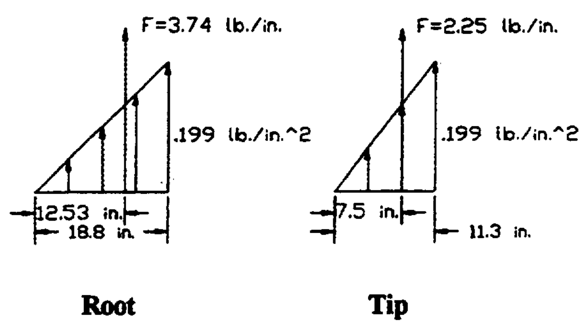



**Figure 3.12: Calculation of Chordwise Resultant for the Vertical Stabilizer at the Root (Left) and the Tip (Right).**

The spanwise load distribution on the vertical stabilizer was simplified by finding the resultant and its location. The resultant load was found to be 119.2 lb. at a distance of 22.5 in from the tip. These were found by calculating the area under the spanwise distribution curve (See Figure 3.13).

$F_{sV.S.} = F_{cV.S.A.} b_{V.S.} = 119.2 \, lb.$ (Resultant of the Spanwise Dist. on the Vert. Stab.)

where: $F_{cV.S.A.} = \frac{F_{cV.S.R.} + F_{cV.S.T.}}{2} = 3.00 \, lb/_{in}$ (Average Chordwise Resultant for the Vert Stab.)

$b_{V.S.} = 39.8 \, in.$ (Span of the Vertical Stabilizer)

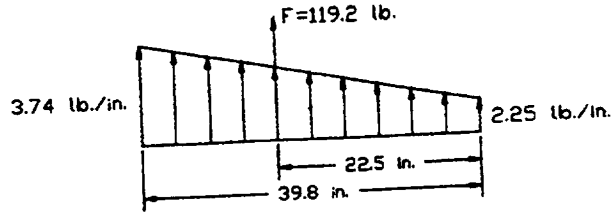



**Figure 3.13: Calculation of Spanwise Resultant for the Vertical Stabilizer.**

### 3.2.8 Loading on the Rudder Due to Deflection.

The chordwise load distribution on the rudder was simplified by finding the resultant and its location. The resultant load distributions were found to be 4.1 lb./in (Root) and 2.1 lb./in (Tip) at distances of 13.7 in (Root) and 6.9 in (Tip) from the trailing edge. These were found by calculating the area under the chordwise distribution curve at the tip and the root (See Figure 3.14).

| | |
|---|---|
| $F_{cR.R.} = .5\overline{w}\, c_{R.R.} = 4.1 \, {}^{lb}\!/\!_{in}$ | (Resultant Force of Chordwise Distribution at the Root) |
| $F_{cR.T.} = .5\overline{w}\, c_{R.T.} = 2.1 \, {}^{lb}\!/\!_{in}$ | (Resultant Force of Chordwise Distribution at the Tip) |
| Where: $\overline{w} = .199 \, {}^{lb}\!/\!_{in^2}$ | (Average Surface Loading on the Vertical Tail) |
| $c_{R.R.} = 20.6 in$ | (Chord of the Rudder at the Root) |
| $c_{R.T.} = 2.63 in.$ | (Chord of the Rudder at the Tip) |

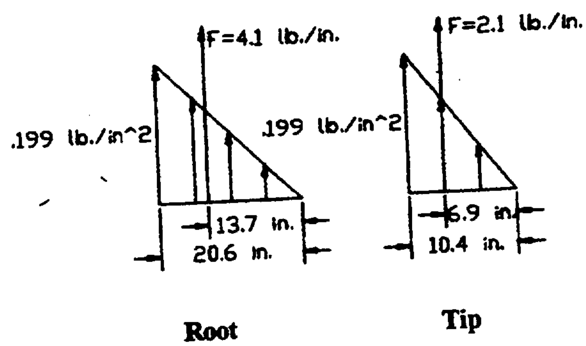



**Figure 3.14: Calculation of Chordwise Resultant for the Rudder at the Root (Left) and the Tip (Right).**

The spanwise load distribution on the rudder was simplified by finding the resultant and its location. The resultant load was found to be 123.4 lb. at a distance of 22 in. from the tip. These were found by calculating the area under the spanwise distribution curve (See Figure 3.15).

| | |
|---|---|
| $F_{sR.} = F_{cR.A.} b_{R.} = 123.4 lb.$ | (Resultant of the Spanwise Dist. on the Rudder) |
| where: $F_{cR.A.} = \dfrac{F_{cR.R.} + F_{cR.T.}}{2} = 3.1 \, {}^{lb}\!/\!_{in}$ | (Average Chordwise Resultant for the Rudder) |
| $b_{R.} = 39.8 in.$ | (Span of the Rudder) |

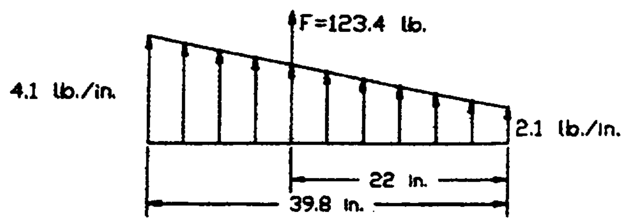



**Figure 3.15: Calculation of Spanwise Resultant for the Rudder.**

### 3.2.9 Load on the Vertical Tail Due to the Maneuvering Case

The load on the vertical tail was determined by adding the loads for the vertical stabilizer and the rudder from the maneuvering case. This resulted in a 242.6 lb. load (See Calculation Below) at a distance of 22.25 in from the tail cone.

$F_{V.T.M.C.} = F_{sV.S.} + F_{sR} = 242.6 lb.$ (Force on Vertical Tail Due to Maneuvering Case)

where: $F_{sV.S.} = 119.2 lb.$ (Resultant of the Spanwise Distribution on the Vert. Stab.)

$F_{sR.} = 1123.4 lb.$ (Resultant of the Spanwise Distribution on the Rudder)

### 3.2.10 Summary of Loads on the Tail Cone (Maneuvering Case)

The following is a summary of the maneuvering case loads and moments on the tail cone. The loads on the two sides of the horizontal tail and the load on the vertical tail were added as vectors. Then the resultant shear force and line of direction were computed to be 454.9 lb. at an angle of 59 degrees from the horizontal (See Calculations Below and Figure 3.16).

$V_{R.M.C.} = \sqrt{(F_{V.T.M.C.})^2 + (2 \times F_{H.T.M.C.})^2} = 454.9 lb.$ (Shear Force on Tail Cone)

$\theta = Sin^{-1} \dfrac{2 \times F_{H.T.M.C.}}{V_{R.M.C.}} = 59°$ (Line of Shear Force Action)

where: $F_{V.T.M.C.} = 242.6 lb.$ (Vertical Tail Load Maneuvering Case)

$F_{H.T.M.C.} = 192.4 lb.$ (Horizontal Tail Load Maneuvering Case)

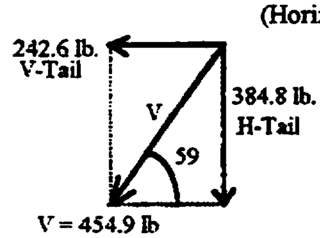



**Figure 3.16: Calculation of the Resultant Shear Force and Line of Action (Maneuvering Case).**

The moment on the tail cone was computed using the method stated in FAR Part 23. This moment was calculated to be 7366 in-lb. (See Equation Below and Figure 3.17).

$T_{M.C.} = .35(F_{H.T.M.C.})(d_{H.M.}) + (F_{V.T.M.C.})(d_{V.M.}) = 7366\,in.\cdot lb.$ (Moment on Tail Cone)

where: $d_{H.M.} = 29.2\,in.$ (Distance from Resultant Force to Tail Cone for Horizontal Tail)

$d_{V.M} = 22.3\,in.$ (Distance from Resultant Force to Tail Cone for Vertical Tail)

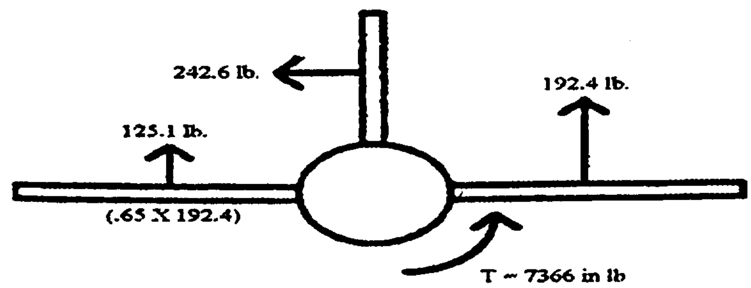



**Figure 3.17: Calculation of the Moment on the Tail Cone for the Maneuvering Case**

**3.2.11 Loading on the Horizontal Tail (Level Cruise Case).**

The chordwise load distribution on the horizontal tail (Level Cruise Case) was simplified by finding the resultant and its location. The resultant load distributions were found to be 6.2 lb./in (Root) and 3.7 lb./in (Tip) at distances of 8.4 in (Root) and 5.01 in (Tip) from the leading edge. These were found by calculating the area under the chordwise distribution curve at the tip and the root (See Figure 3.18).

$$F_{c.H.T.R.} = .5\overline{w}(.75)c_R + \overline{w}(.25)c_R + .5(3)\overline{w}(.25)c_R = 6.2\,{}^{lb}\!/_{in}$$

(Resultant Force of Chordwise Distribution at the Root)

$$F_{c.H.T.T.} = .5\overline{w}(.75)c_T + \overline{w}(.25)c_T + .5(3)\overline{w}(.25)c_T = 6.2\,{}^{lb}\!/_{in}$$

(Resultant Force of Chordwise Distribution at the Tip)

Where: $\overline{w} = .260\,{}^{lb}\!/_{in^2}$ (Average Surface Loading on the Horizontal Tail)

$c_R = 23.9\,in.$ (Chord of the Horizontal Tail at the Root)

$c_T = 14.3\,in.$ (Chord of the Horizontal Tail at the Tip)

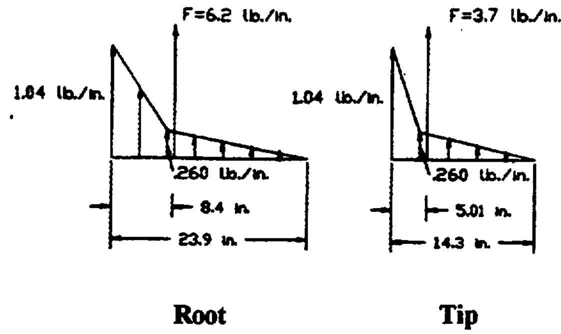



**Figure 3.18: Calculation of Chordwise Resultant for the Horizontal Tail (Level Cruise Case) at the Root (Left) and the Tip (Right).**

The spanwise load distribution for the Horizontal Tail (Level Cruise Case) was simplified by finding the resultant and its location. The resultant load was calculated to be 300.0 lb. at a distance of 32.9 in from the tip. This was found by calculating the area under the spanwise distribution curve (See Figure 3.19).

$F_{s.H.T.} = F_{c.H.T.A.} b_{H.T.} = 300.0\,lb.$ (Resultant of the Spanwise Dist. on the Horiz. Tail)

where: $F_{c.H.T.A.} = \dfrac{F_{c.H.T.R.} + F_{c.H.T.T.}}{2} = 4.95\,{}^{lb}\!/\!_{in}$ (Average Chordwise Resultant for the Horiz. Tail)

$b_{H.T.} = 60.6\,in.$ (Span of the Horizontal Tail)

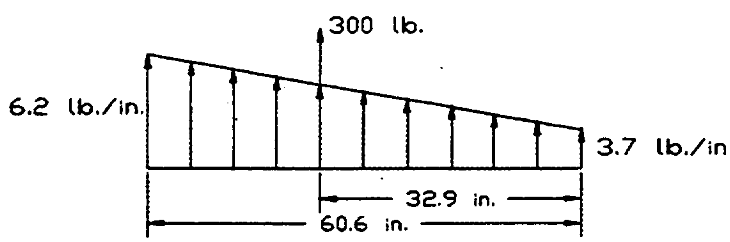



**Figure 3.19: Calculation of Spanwise Resultant of the Horizontal Tail (Level Cruise Case).**

### 3.2.12 Loading on the Vertical Tail (Level Cruise Case).

The chordwise load distribution on the vertical tail (Level Cruise Case) was simplified by finding the resultant and its location. The resultant load distributions were found to be 7.92 lb./in (Root) and 4.86 lb./in (Tip) at distances of 13.8 in (Root) and 7.63 in (Tip) from the leading edge. These were found by calculating the area under the chordwise distribution curve at the tip and the root (See Figure 3.20).

$$F_{c.V.T.R.} = .5\overline{w}(.75)c_R + \overline{w}(.25)c_R + .5(3)\overline{w}(.25)c_R = 7.92\,{}^{lb}\!/\!_{in}$$

(Resultant Force of Chordwise Distribution at the Root)

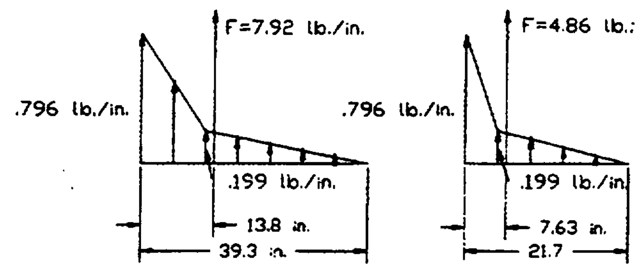
$$F_{c.V.T.T.} = .5\overline{w}(.75)c_T + \overline{w}(.25)c_T + .5(3)\overline{w}(.25)c_T = 4.86\,{}^{lb}\!/\!_{in}$$

(Resultant Force of Chordwise Distribution at the Tip)

Where: $\overline{w} = .199\,{}^{lb}/_{in^2}$ (Average Surface Loading on the Vertical Tail)

$c_R = 39.3\,in.$ (Chord of the Vertical Tail at the Root)

$c_T = 21.7\,in.$ (Chord of the Vertical Tail at the Tip)




**Root** **Tip**

**Figure 3.20: Calculation of Chordwise Resultant for the Vertical Tail (Level Cruise Case) at the Root (Left) and the Tip (Right).**

The spanwise load distribution on the vertical tail (Level Cruise Case) was simplified by finding the resultant and its location. The resultant load was calculated to be 254.3 lb. at a distance of 21.5 in. from the tip. This was found by calculating the area under the spanwise distribution curve (See Figure 3.21).

$F_{sV.T.} = F_{cV.T.A.} b_{V.T.} = 254.3\,lb.$ (Resultant of the Spanwise Dist. on the Vertical Tail)

where: $F_{cV.T.A.} = \dfrac{F_{cV.T.R.} + F_{cV.T.T.}}{2} = 6.39\,{}^{lb}/_{in}$ (Average Chordwise Resultant for the Vertical Tail)

$b_{V.T.} = 39.8\,in.$ (Span of the Vertical Tail)

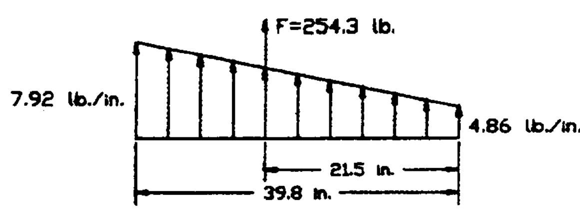



**Figure 3.21: Calculation of Spanwise Resultant for the Vertical Tail (Level Cruise Case)**

### 3.2.13 Summary of Loads Resulting on the Tail Cone (Level Cruise Case)

The following is a summary of the level cruise case loads and moments on the tail cone. The loads on the two sides of the horizontal tail and the load on the vertical tail were added as vectors. Then the resultant shear force and line of action were computed to be 651.7 lb. at an angle of 67 degrees from the horizontal (See Calculations Below and Figure 3.22).

$$V_{R.L.C.} = \sqrt{(F_{V.T.L.C.})^2 + (2 \times F_{H.T.L.C.})^2} = 651.7 lb.$$ (Shear Force on Tail Cone)

$$\theta = Sin^{-1} \frac{2 \times F_{H.T.L.C.}}{V_{R.L.C.}} = 67°$$ (Line of Shear Force Action)

where: $F_{V.T.L.C.} = 254.3 lb.$ (Vertical Tail Load Maneuvering Case)

$F_{H.T.L.C.} = 300.0 lb.$ (Horizontal Tail Load Maneuvering Case)

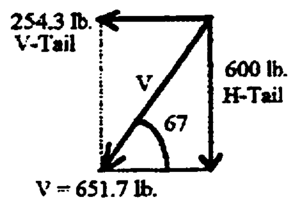



**Figure 3.22: Calculation of the Resultant Shear Force and Line of Action (Level Cruise Case).**

The moment on the tail cone was computed using the method stated in FAR Part 23. This moment was calculated to be 8955 in-lb. (See Equation Below and Figure 3.23).

$$T_{L.C.} = .35(F_{H.T.L.C.})(d_{H.L.}) + (F_{V.T.L.C.})(d_{V.L.}) = 8955 in.\cdot lb.$$ (Moment on Tail Cone)

where: $d_{H.L.} = 32.9 in.$ (Distance from Resultant Force to Tail Cone for Horizontal Tail)

$d_{V.L.} = 21.5 in.$ (Distance from Resultant Force to Tail Cone for Vertical Tail)

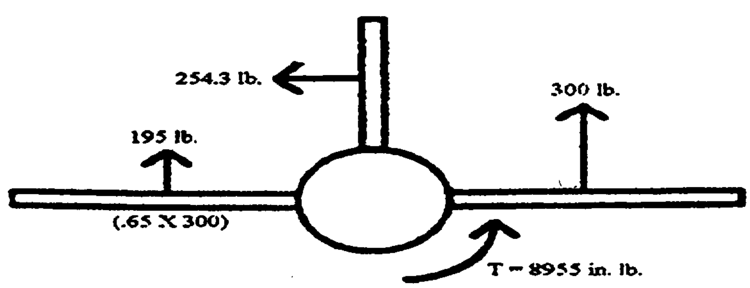



**Figure 3.23: Calculation of the Moment on the Tail Cone for the Maneuvering Case**

### 3.2.14 Snow Loads

The snow loads were analyzed for ten inches of wet snow. The volume of the snow on the empennage and mid-section was calculated using the planform area of these sections times ten inches for the snow depth. The volume of the wet snow was found to be 60,240 cubic inches. The density of wet snow was found in the documentation for the first Triton design. This density was found to be 0.00694 lb./in. The maximum shear force for all the snow on the empennage and mid-section was found to be 418.3 lb. This shear force is not the worst case scenario, therefore, it can be ignored.

### 3.2.15 Tie Down Loads

The tie down loads were calculated for wind gusts up to 120 mph. The standard lift equation was used with data from the 2-D lift curve slope for the horizontal tail. The lifting force generated by the NACA-0009 airfoil and a 120 mph gust was found to be 492 lb. (See Calculation Below). This force is not the worst case scenario for shear forces on the empennage or mid-section, but is important in the local sizing of the of the tie-down bolt.

$$L=\left[\frac{a_o}{1+\frac{57.3a_o r}{\Pi(AR)}}\right]\alpha\frac{1}{2}\rho V^2 S=492\,lb.$$ (Tie Down Force Resulting from 120 mph. Gust)

Where: $a_o = .11\ per^\circ$ (2-D lift curve slope for NACA 0009)

$r = .85$ (Value from Perkins and Hage for Horizontal Stabilizer)

$\alpha = 10^\circ$ (Angle of Incidence, Required by S.O.W.)

$\rho = .002378\ {}^{slugs}/_{ft^3}$ (Density of Air at Sea Level)

$V = 176\,fps$ (Velocity Equivalent to 120 mph, Required by S.O.W.)

$S = 15.6\,ft^2$ (Planform of the Horizontal Tail)

$AR = 6$ (Aspect Ratio of the Horizontal Tail)

## 3.3 Loads and Loading for Control System

The loading on the elevators and ailerons showed that a ratio of approximately three to one was needed to meet the requirements of FAR Part 23 for the maximum load a pilot can see. The side stick is allowed to have 67 pounds maximum for aileron deflection. The ailerons use a bell crank to get the three to one ratio needed to meet the requirements of FAR Part 23. FAR Part 23 requires that the maximum load on the pilot not exceed 167 lb. for elevator deflection using a stick .

## 3.4 Loads on the Rudder Control System

### 3.4.1 Loads on the Toe Brake

The toe brake pivots on the bearing at point A. The FAR's maximum allowable load of 200 lb., which is supplied by the controller, will generate reactant forces at A and B. To create the maximum load on points A and B, the following calculations are when the master cylinder will be fully compressed.

Summing the moments about A (See Figure 3.24)

$$P_{max} \times X_1 - P_B \times X_2 = 0$$
$$P_B = 266.7lbs$$

Where: $P_{max}$ = 200 lb.
$X_1$ = 2 in
$X_2$ = 1.5 in

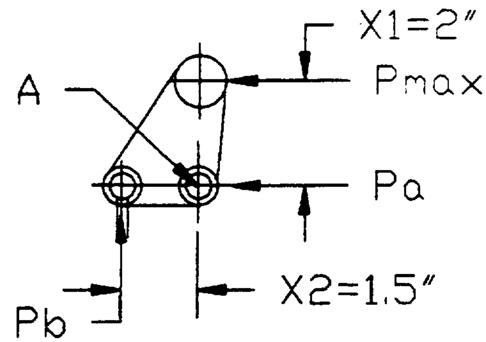



**Figure 3.24: Forces on the Toe Brake**

Summing the forces in the X and Y plane (See Figure 3.24)

$$P_{AX} - P_{max} - P_{max} \times \sin\theta = 0$$
$$P_{AX} = 291.2lbs$$
$$P_{max} \times \cos\theta - P_{AY} = 0$$
$$P_{AY} = 250.6lbs$$
$$P_A = \sqrt{P_{AX}^2 + P_{AY}^2} = 384.2lbs$$

Where: $\theta = 20°$
$P_{max}$ = 200 lb.

### 3.4.2 Loads on the Rudder Pedal

To obtain the largest value for forces $P_C$ and $P_D$ the pedal needs to be in the neutral position with an applied force of 200 lb. at the toe brake. This causes the largest moment.

Summing moments about point C (See Figure 3.25).

$$P_D \times X_3 - P_{max} \times X_4 = 0$$
$$P_D = 346.7lbs$$

Where: $X_3 = 3.75in$
$X_4 = 6.50in$
$P_{max} = 200lbs$

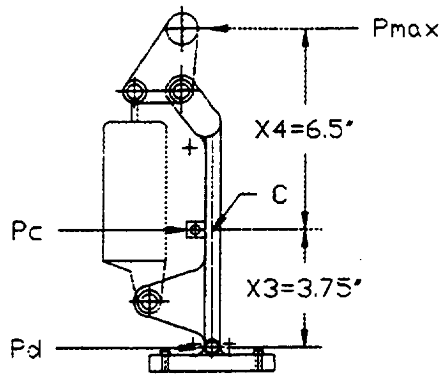



**Figure 3.25: Forces on the Rudder Pedal**

Summing the forces in the X plane (See Figure 3.25)

$P_C - P_{max} - P_D = 0$ Where: $P_D = 346.7lbs$

$P_C = 546.7lbs$ $P_{max} = 200lbs$

### 3.4.3 Forces on the Rudder Pedal Mounts

Summing forces in the X plane (See Figure 3.26)

$P_C - N_{bolt} \times P_{bolt} = 0$ Where: $N_{bolt} = 4$

$P_{bolt} = 86.7lbs$ $P_D = 346.7lbs$

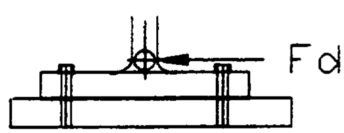



**Figure 3.26: Forces on the Rudder Pedal Mounts**

### 3.4.4 Forces on the Actuator Crank

#### 3.4.4.1 Forces on Actuator Center Nut (Point E)

The load that is carried through the push-pull rods is 546.7 lb. which will be applied to the pedal actuated crank as shown in Figure 3.27. The bell-crank will be under maximum load when the pilot uses full braking on both pedals. This yields $P_{center}$, $P_{wire}$, and $P_{gear} = 0$.

Summing forces in the X plane (See Figure 3.27).

$P_C + P_C - P_E = 0$ Where: $P_C = 546.7lbs$

$P_E = 1{,}093lbs$

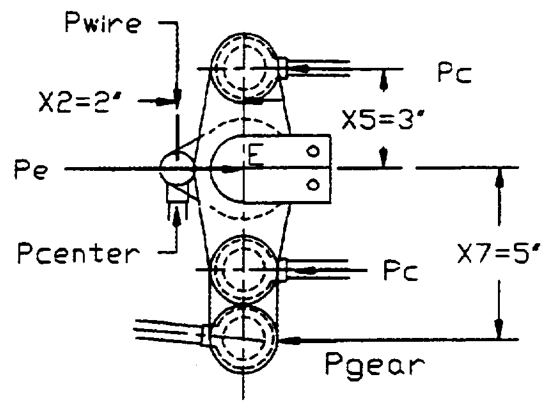



**Figure 3.27: Forces on the Actuator Crank**

#### 3.4.4.2 Forces Within the Center Rod

The maximum axial load will occur when the pilot loads only one brake and the center rod resists this load. Assume $P_{gear} = 0$.

Summing the moments about E (See Figure 3.27).

$$P_C \times X_5 - P_{center} \times X_6 = 0 \qquad \text{Where: } X_5 = 3in$$
$$P_{center} = 820lbs \qquad X_6 = 2in$$
$$P_C = 546.7lbs$$

#### 3.4.4.3 Forces Within the Front Rod.

To obtain the maximum force found within the push-pull rod, the pilot applies maximum force to only one of the brake pedals. Assuming $P_{wire}$ and $P_{center} = 0$.

Summing moments about E (See Figure 3.27)

$$P_{gear} \times X_7 - P_C \times X_5 = 0 \qquad \text{Where: } X_7 = 5in$$
$$P_{gear} = 328.0lbs \qquad X_5 = 3in$$
$$P_C = 546.7lbs$$

### 3.4.5 Wire Tension Forces

The pulley wire experiences maximum force when the center rod will oppose the $P_{center}$.

Therefore $P_{wire}$ = 820 lb..

### 3.4.6 Forces on the Center Crank

The maximum force occurs when both pilots act in unison.

Summing forces at F in the Y-plane (See Figure 3.29).

$P_{center} - P_{center} + P_{pivot} = 0$ Where: $P_{center} = 820lbs$

$P_{pivot} = 1{,}640lbs$

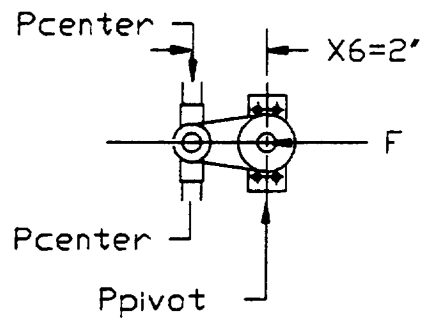



**Figure 3.28: Forces on the Center Crank**

### 3.4.7 Pulley Bearings Forces.

The maximum force that the pulley bearing experiences is when the wire is in tension in both the X and Y plane.

Finding the resultant force (See Figure 3.29).

$P_{pulley} = \sqrt{P_{wire}{}^2 + P_{wire}{}^2}$ Where: $P_{wire} = 820lbs$

$P_{pulley} = 1160lbs$

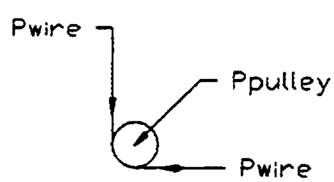



**Figure 3.29: Force on the Pulley Bearing**

## 4. Structural Substantiation

### 4.1 Structural Substantiation for the Safety Cage

To calculate the size needed for the members of the safety cage to sustain the loadings as described in section 3.1, a series of calculations were performed. These calculations where based on the premonition that the forces will dictate the size of the members.

### 4.1.1 Sizing for the Safety Cage

From the loading conditions for the safety cage, the size needed for each member can be found. This can be done by using the following formula:

$$P = \frac{\pi^2 EI}{l^2}$$

Where:

P = axial load
E = Modules of elasticity
I = Moment of inertia
l = length

By solving for the moment of inertia, the area of the cross section of the beam can be found. Using this formula the moment of inertia can be found for load case 1:

$$P = 1800\,lbs$$

$$E = 1x10^7\,\frac{lbs}{in^2}$$

$$l = 86.6in$$

$$F.S. = 1.5$$

$$I = \frac{1800\,lbs(1.5)(86.6in)^2}{\pi^2(1x10^7\,lbs/in^2)}$$

$$I = 0.2565\,in^4$$

In these calculations a factor of safety (F.S.) was used in accordance with FAR Part 23.

For case studies 4 and 5 of the loading condition, the members where at an angle to the force. Since the beams were not two force members, an added moment was caused by the force. This must be taken into consideration. To allow for this, a modification must be made to the equation:

$$I_{CR} = \frac{I}{R}$$

Where:

$I_{CR}$ = Critical Moment of Inertia
I = Moment of Inertia
R = Correction factor

$$I = 0.1084\,in^4$$
$$R = 0.38\ (From Fig 5.2.17, p.130\ Nui)$$
$$I_{CR} = \frac{0.1084}{0.38}$$
$$I = 0.2852\,in^4$$

The following chart shows the moment of inertia for each load case (See Table 4.1):

**Table 4.1: Moment of Inertia**

| Case load | Moment of inertia |
|---|---|
| 1 | 0.2565 $in^4$ |
| 2 | 0.01387 $in^4$ |
| 3 | 0.0566 $in^4$ |
| 4a<br>4b | 0.2852 $in^4$<br>0.2202 $in^4$ |
| 5a<br>5a | 0.282 $in^4$<br>0.115 $in^4$ |
| 6 | 0.342 $in^4$ |

#### 4.1.2 Cross-sectional Area

For easier fabrication of the safety cage, it was decided that a single cross-sectional area will be used for all the members. For this reason the highest moment of inertia will be chosen for the sizing of the safety cage members. To size the members the following formula was used:

$$I_{total} = \sum I_i = \frac{1}{12} b_i h_i^3 + A_i d_i^2$$

Where

$I_{total}$ = Total moment of inertia
$I_i$ = Moment of inertia for section
$b_i$ = Base of section
$h_i$ = Height of section
$A_i$ = Area of section
$d_i$ = Distance from the neutral axis to the center of section

Knowing that the moment of inertia is based on the cross-sectional area of the beam, a mathematical formula can be found linking the area to the moment. The following formula is based on the presumption that all the members will have a hat-shaped cross-section (See Figure 4.1)

$$I_1 = 2\left[\frac{1}{12}b_f t^3 + \left(b_f t\left(\bar{y} - \frac{t}{2}\right)^2\right)\right]$$
$$I_2 = 2\left[\frac{1}{12}t h_c^{\,3} + \left(t h_c\left(\bar{y} - \frac{h_c}{2}\right)^2\right)\right]$$
$$I_3 = \left[\frac{1}{12}b_5 t^3 + \left(b_5 t\left(\bar{y} - \frac{t}{2}\right)^2\right)\right]$$
$$I = I_1 + I_2 + I_3$$
*where:*
$$\bar{y} = \frac{\left[2\left(h_c + \frac{t}{2}\right)b_f\, t\right] + \left[2\left(\frac{h_c}{2}h_c\, t\right)\right] + \left(\frac{t}{2}b_5\, t\right)}{t\left(2b_f + 2h_c + b_5\right)}$$

Where: t = Thickness of metal
$h_c$ = Height of channel
$b_f$ = Length of flange
$b_5$ = Width of channel
y = Neutral axis location
I = Total moment of inertia
$I_1$ = Moment of inertia of flange
$I_2$ = Moment of inertia of side channel
$I_3$ = Moment of inertia of bottom of channel

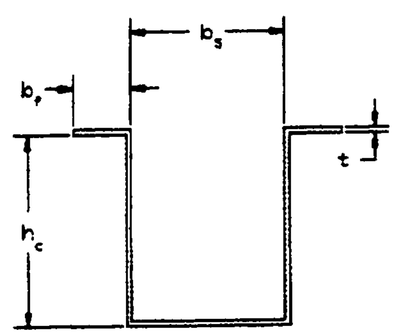



**Figure 4.1: Dimension Notation for Formula**

Allowing the equation to be solved using variables for t, $h_c$, $b_f$, and $b_5$ the correct moment of inertia can be found. Using MathCAD the following dimensions where found (See Figure 4.2):

t = 0.063 in
$h_c$ = 2.5 in
$b_f$ = 0.75
$b_5$ = 2.0 in
I = 0.475 in$^4$

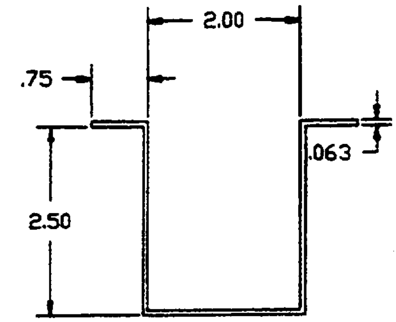



**Figure 4.2: Hat -channel Dimensions for Safety Cage**

Because the wing section will be attached to the cage, it was also decided for ease of attachment, the top portion of the cage will be constructed out of square tubes. Using the maximum moment of inertia as a reference point, the calculations for the top beams were carried out the same way. From the procedure, the cross-section was calculated to be 2.2 in by 2.2 in (See Figure 4.3).

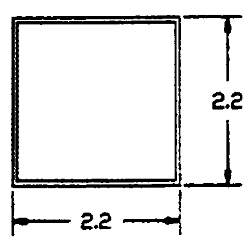



**Figure 4.3: Square Dimension for Safety Cage**

**4.2 Structural Substantiation for the Mid-Section and Empennage**

In order to simplify the sizing process for the mid-section and empennage, it was assumed that these parts were circular cylinders of various sizes (See Figure 4.4). Each cylinder has four stringers. The first stringer would be placed 45 degrees from the vertical with all other stringers placed 90 degrees apart. The inspiration for this technique was provided by the previous design for the Triton. This assumption is conservative, therefore, the only draw back is the mid-section and the tail might be slightly over designed. Note that critical design loads for the tail were used.

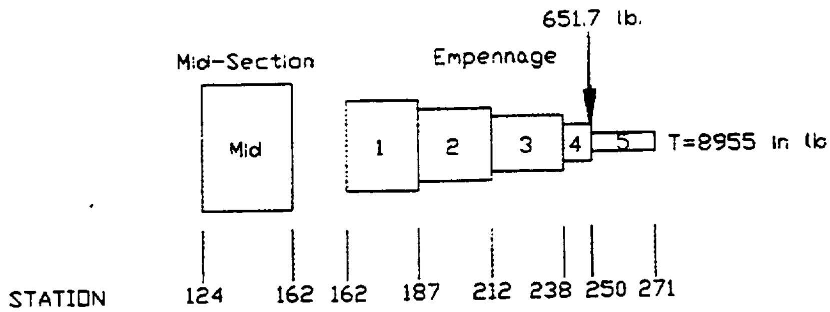



**Figure 4.4: Circular Cylinder for Sizing Approximation**

### 4.2.1 Sizing the Skin

The buckling equation was used to determine the required skin thickness. The initial skin sizing was performed with 0.025" thick aluminum, but it was found that 0.020" thick, 2024-T3 aluminum was sufficient to provide for the critical buckling strength. For each panel of the midsection and the empennage, the actual shear stress and critical buckling stress were computed (See Table 4.2 and Calculations Below). The margin of safety was then calculated. The length of panel three (See Figure 4.4) provided the lowest margin of safety. This margin of safety was .003; and is the critical design criterion for the skin sizing of the empennage. The mid-section consisted of only one panel; and its margin of safety was .56 (See Table 4.2). It should be noted that panel five has no loads on it at all. It merely exists for aesthetic reasons.

Calculation for Actual Shear Stress:

$f_{shear} = q/t = 830\,psi$ (Actual Shear Stress for Panel One)

where: $q = T/2A = 16.6\,lb/in.$ (Shear Flow Equation for Panel One)

where: $T = 8955\,in \cdot lb$ (Tail Load Torque for Worst Case)

$A = \frac{\pi}{4}(d^2) = 270\,in^2$ (cross-sectional Area of Panel One)

where: $d = 18.54\,in.$ (Diameter of the Circular Cylinder in Panel One)

Calculation for Critical Buckling Stress:

$f_{crit} = K_s E(t/b)^2 = 1890\,psi$ (Critical Buckling Stress for Panel One)

where: $K_S = 300$ (Conservative, Panel Stiffness, Nui Fig. 5.4.8)

$E = 10 \times 10^6\,psi$ (Modules of Elasticity for Aluminum)

$t = 0.020\,in.$ (Skin Thickness)

$b = 25.2\,in.$ (Length of Panel One)

**Table 4.2: Summary of Skin Sizing Calculations.**

| Panel | Length (in.) | Shear Flow, q (lb./in) | $K_S$ | $f_{shear}$ (psi) | $f_{crit}$ (psi) | Margin of Safety |
|---|---|---|---|---|---|---|
| 1 | 25.2 | 16.6 | 300 | 830 | 1890 | 1.3 |
| 2 | 25.2 | 24.0 | 300 | 1200 | 1890 | 0.6 |
| 3 | 25.2 | 37.7 | 300 | 1885 | 1890 | 0.0030 |
| 4 | 12.6 | 49.4 | 225 | 225 | 5669 | 1.3 |
| 5 | 21.8 | No Load | N/A | N/A | N/A | N/A |
| Mid | 35.6 | 12.1 | 300 | 607 | 949 | 0.56 |

### 4.2.2 Sizing of the Stringers

The stringers must be sized for two conditions. The stringers could buckle as a result of the applied moment or due to the excessive former spacing. It was found that 0.020" thick, 2024-T3 aluminum was enough to provide sufficient strength for the empennage, but 0.040 thick, 2024-T3 aluminum was needed for the mid-section.

#### 4.2.2.1 Failure Due to the Applied Moment

For each panel of the mid-section and the empennage, the bending stress of the stringers was computed and compared to the material strength (See Table 4.3 and Calculations Below). The margin of safety was then calculated. Panel one (See Figure 4.4) provided the lowest margin of safety. This margin of safety was 0.85. The mid-section consisted of only one panel and its margin of safety was 1.23 (See Table 4.3). It should be noted that panel five has no moment on it at all. It merely exists for aesthetic reasons.

$f_{bend} = \dfrac{Md_\perp}{I} = 21{,}050\,psi$ (Bending Stress Due to Applied Moment)

where: $M = 57{,}480\,in \cdot lb$ (Max. Moment for Panel One)

$d_\perp = d_z \sin(68^\circ) = 10.0\,in.$ (Perpendicular Distance from Neutral Axis)

$I = 4(A_{stringer} dz^2) = 27.3\,in^4$ (Moment of Inertia for the Cross Section)

$d_z = 10.8\,in.$ (Distance from center to Stringer)

$A_{stringer} = 0.058\,in^4$ (Area of Each Stringer)

Table 4.3: **Summary of Data for Failure Due to Applied Moment**

| Panel Section | $d_z$ (in.) | $d_{perp.}$ (in.) | Moment (in lb.) | I ($in^4$) | $f_{bend}$ (psi) | $f_{mat.\ str.}$ (psi) | Margin of Safety |
|---|---|---|---|---|---|---|---|
| 1 | 10.8 | 10.0 | 57 480 | 27.3 | 21 050 | 39 000 | 0.85 |
| 2 | 9.3 | 8.6 | 41 060 | 19.9 | 17 710 | 39 000 | 1.20 |
| 3 | 7.7 | 7.1 | 24 630 | 13.8 | 12 670 | 39 000 | 2.10 |
| 4 | 6.2 | 5.7 | 8 211 | 8.8 | 5 320 | 39 000 | 6.30 |
| 5 | 5.4 | 5.0 | 0 | 6.7 | 0 | 39 000 | Infinite |
| mid | 18.5 | 17.1 | 80 650 | 79.1 | 17 470 | 39 000 | 1.23 |

#### 4.2.2.2 Buckling Due to the Panel Length and Average Stress

For each panel of the midsection and the empennage, the average shear stress and critical buckling stress were computed for each stringer (See Table 4.4 and Calculations Below). The margin of safety was then calculated. Panel one (See Figure 4.4) provided the lowest margin of safety. This margin of safety was 0.38 and is therefore the critical design criterion for the stringer sizing of the empennage. The mid-section consisted of only one panel and its margin of safety was 0.066 (See Table 4.4). It should be noted that the moment of inertial and stringer area for the mid-section are different than those given for the empennage stringers. The moment of inertia for each mid-section stringer is 0.026 $in^4$; and the area is 0.102 $in^2$.

$$f_{crit} = \frac{\pi^2 EI_{Stringer}}{Al^2} = 26{,}800\,psi$$ (Critical Buckling Strength for the Stringer)

where: $E = 10\times10^6\,psi$ (Modules of Elasticity for Aluminum)

$I_{stringer} = 0.01\,in^4$ (Moment of Inertia for an Empennage Stringer)

$A_{stringer} = .058\,in^2$ (Area of an Empennage Stringer)

$l = 25.2\,in.$ (Length of Panel 1-2)

**Table 4.4: Summary of Data for Average Stress and Critical Buckling Strength**

| Panel Section | $f_{avg}$ (psi) | $f_{crit}$ (psi) | Margin of Safety |
|---|---|---|---|
| 1-2 | 19 380 | 26 800 | 0.38 |
| 2-3 | 15 200 | 26 800 | 0.76 |
| 3-4 | 9 000 | 26 800 | 2.0 |
| 4-5 | 2 660 | 107 000 | 39.0 |
| mid | 19 260 | 20 537 | 0.066 |

### 4.2.3 Fatigue Analysis for the Stringers

The fatigue analysis was performed using the simplification process below (See Calculations Below). After the maximum, mean and cyclic maximum stresses were found, Figure 15.4.5 in Nui was used to determine the safe life. The highest risk for fatigue failure resulted in panel one. The margin of safety for this panel was 3.0. For a summary of all the fatigue data for the empennage stringers see Table 4.5.

$$f_{max} = \frac{Md_{\perp}}{I} = 21{,}050\,psi \qquad \text{(Bending Stress Due to Applied Moment)}$$

where: These calculations were performed in the Failure Due to Applied Moment, Section 4.2.2.1

$$f_{cyc\,max} = \frac{f_{max}}{2} = 10{,}530\,psi \qquad \text{(Maximum Cyclic Loading)}$$

$$f_{mean} = \frac{f_{max}}{4.4} = 4{,}780\,psi \qquad \text{(Mean Stress)}$$

**Table 4.5: Fatigue Summary for the Empennage Stringers**

| Panel Section | $f_{max}$ | $f_{cyc\,max}$ | $f_{mean}$ | Cyclic Life | M.S. |
|---|---|---|---|---|---|
| 1 | 21 050 | 10 530 | 4 780 | $4x10^6$ | 3 |
| 2 | 17 710 | 8 900 | 4 030 | $3x10^7$ | 29 |
| 3 | 12 670 | 6 300 | 2 880 | Infinite | Infinite |
| 4 | 5 320 | 2 600 | 1 210 | Infinite | Infinite |

### 4.2.4 Rivet Selection and Spacing

The MS20430DD-2-3 rivet was selected for the skin. Four conditions had to be satisfied in order to select the rivets for the Triton II; they are as follows:

1. The rivets must be able to withstand the shear stress associated with the application.
2. The rivet must be compatible with material thickness.
3. The rivets can be no closer than four rivet diameters apart; and they can be no farther than eight rivet diameters apart.
4. In areas were fatigue life is important, the rivet must have appropriate fatigue life.

For 0.020" thick, 2024-T3 aluminum; the maximum rivet diameter was found to be 1/16 in. The maximum shear flow for any point on the surface of the skin was found to be 60.16 lb./in. The material shear strength for an aluminum 1/16 in. rivet was divided by the maximum shear flow. This gave a rivet spacing of 2.27 inches; but this distance violates the rivet spacing rule. The maximum allowed rivet spacing was then chosen. Thus, each rivet will be place 0.5 inches apart. Because the maximum rivet spacing was much less than the needed rivet spacing, the fatigue life was not even a factor.

MS20430DD-3-4 and MS20430DD-3-5 rivets were selected for the horizontal and vertical tail interfaces. The same method was used on these rivets. Again, the most critical factor in their sizing was the maximum rivet spacing rule.

#### 4.2.5 Tie Down Bolt, Nut, and Washer Selection

As was found in the Loads and Loading section, the tie down force is 492 lb. An AN6 size eye bolt, an AN960-D616 washer, and an AN315-6 nut were selected. An aluminum, AN6 bolt has a tensile strength 5020 lb. Thus, the margin of safety was found to be 9.2. As can be seen in drawing S94-1A-301-1B, the area local to the tie down bolt has been doubled to prevent bolt tear out.

#### 4.2.6 Mid-Section and Empennage Interface Bolts, Nuts, and Washer Selection

For the mid-section and empennage interfaces, the maximum tensile force was found to be 659 lb./bolt, and the maximum shear force was found to be 5026 lb. per bolt. An AN8DD6 bolt, an AN960-D816L washer, and an AN365-D820 nut were selected. An aluminum, AN8 bolt has a tensile strength 9180 lb.; and a shear strength of 6850 lb. Thus, the margins of safety were found to be 9.4 and 0.83 respectively. The spacing and orientation can be seen in drawing S94-1A-301-1B.

#### 4.2.7 Horizontal and Vertical Tail Interface Bolts, Nuts, and Washer Selection

For the horizontal and vertical tail interfaces, the maximum shear force was found to be 934 lb./bolt. An AN4DD4 bolt and an AN315-D4 nut were selected. An aluminum, AN4 bolt has a shear strength of 1715 lb. Thus, the margin of safety was found to be 0.84. The spacing and orientation can be seen in drawing S94-1A-301-1B. Further, the maximum stress for these bolts was found to be 19,000 lb./sq. in. The maximum cyclic stress and the mean stress were found to be 9,520 lb./sq. in. and 4,318 lb./sq. in., respectively. Thus, the maximum safe life was found to be $1 \times 10^7$ cycles. The margin of safety for fatigue was found to be 10.0.

### 4.3 Structural Substantiation for Elevator and Aileron Control System

The cables were chosen because of their ability to withstand 480 pounds of force. The bell cranks were used to keep the cables from seeing higher loads. The Aluminum stick assembly was found to be adequate by using the displacement equations.

$$\phi = \frac{Tl}{JG}$$

Where:

T = Torque
l = Length
J = Polar Moment of Inertia
G = Shear Modules

$$\delta = \frac{Pl^3}{3EI}$$

Where:

P = Axial Force
l = Length
E = Modules of Elasticity
I = Moment of Inertia

It was calculated that a displacement of 0.03"occurs under the worst condition of the pilots creating the most torque. When two pilots oppose one another, one exerts 70 percent of the maximum force allowed, while the other exerts the maximum allowed. Under this condition the displacement is even smaller. This allows an aluminum tube to be used instead of a steel tube, reducing weight. Using the tube instead of a solid rod gives it greater resistance to torsion.

### 4.4 Structural Substantiation for Rudder Control System

Within the rudder system, most parts have been oversized to ensure that no failure occurs. The push-pull rods will be analyzed to ensure that they will not buckle under maximum applied stress. The push-pull rod used for this analysis will be the longest one which leads to the front wheel of the aircraft. The other rods within the rudder system are shorter with the same material properties and diameters. The next part to be sized will be the actuator crank to ensure that it will not fail. This part has three rotating balls that permit adequate rotational space for the interface between the rod ends and the crank.

#### 4.4.1 Critical Buckling Loads Within the Push-Pull Rod

Determining the ultimate buckling load within the push-pull rod

$$I = \frac{\pi}{4}(C_D^4 - C_I^4) = 0.002148in^4 \qquad \text{Where: } C_D = 0.25in$$

$$C_I = 0.185in$$

$$P_{crit} = \pi^2 EI/l^2 = 434.5lbs \qquad \text{Where: } E = 10 \times 10^6 psi$$

$$I = 0.002148in^4$$

$$l = 22.09in$$

The $P_{gear}$ load determined in 3.3.6 with a fitting factor of 1.2

$P_{critFF} = 393.6lbs$

Determining the margin of safety

$M.S. = P_{crit} / P_{gearFF} = 1.10$

**4.4.2 Sizing of the Actuator Crank.**

This part is made out of 2024-T3 plate that has been blanked and then press formed. The maximum forces used within this evaluation were derived in the Loads and Loading section above. There are five locations that will be evaluated for tear out and bearing stresses ( See Figure 4.5). The area calculations can be found in the internal report.

At the Crank end with $P_C = 546.7lbs$

a. Bearing stress at the top and bottom of ball bearing

$f_{brg} = P_C / A_1$ Where: $A_1 = 0.2146in^2$

$f_{brg} = 2,548psi$

b. Bearing stress at center of ball bearing

$f_{brg} = P_C / A_2$ Where: $A_2 = 0.6080in^2$

$f_{brg} = 899.2psi$

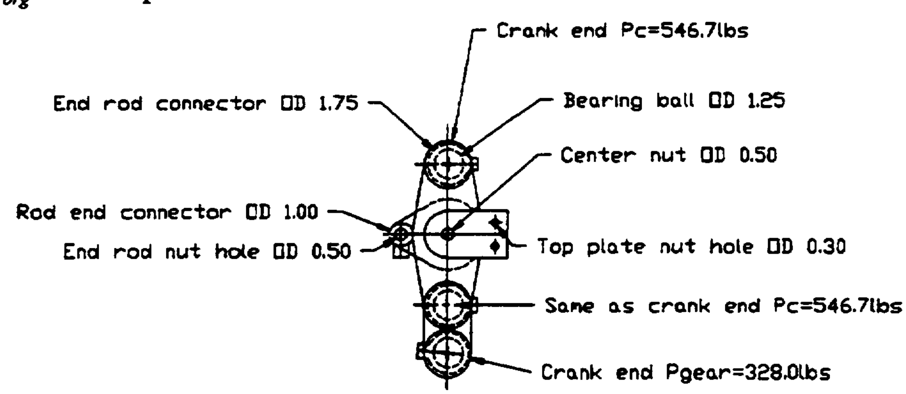



**Figure 4.5: Summary of Actuator Sizing**

c. Tear out stress of the end connector

$f_{t.o.} = P_C / A_3$ Where: $A_3 = 0.1238in^2$

$f_{t.o.} = 4,416psi$

d. Shear stress at the top and bottom of the bearing ball

$f_{shear} = P_C / A_4$ Where: $A_4 = 0.6136 in^2$

$f_{shear} = 891.0 psi$

The following are the other stress values that have been calculated on the actuator crank. The following 2024-T3 values were used: $f_{ubrg} = 85ksi, f_{lbrg} = 60ksi, f_{ut} = 60ksi, f_{lt} = 44ksi$ (See Table 4.6).

**Table 4.6: Critical Bearing and Tear Out Stresses for the Actuator Crank**

| Location | $f_{brg}$ (psi) | $f_{t.o.}$ (psi) | $M.S._{ul}$ (psi) | $M.S._{ll}$ (psi) |
|---|---|---|---|---|
| Crank end with $P_C = 546.7lbs$ | 2,548 | 4,416 | 1.68 | 1.25 |
| Crank end with $P_{gear} = 328.0lbs$ | 1,528 | 2,649 | 2.80 | 2.06 |
| End rod nut | 3,280 | 3,280 | 4.57 | 3.35 |
| Center nut | 4,373 | 4,373 | 3.43 | 2.52 |
| Top plate nut | 3,644 | 1,562 | 5.76 | 4.23 |

# 5. Manufacturing and Maintenance Provisions

## 5.1 Safety Cage Manufacturing

In the design of the safety cage, commonalty of parts was utilized. Since there are many standard parts for the safety cage, it is feasible to order large quantities of standard stock sheet metal. Therefore, one process can be used to break form the metal sheets after they have been cut to length. To form the top beam members of the safety cage, standard stock square tubes will be ordered. In both cases 2024-T3 aluminum will be used.

To help in the fabrication of the cage, preformed joints will be utilized. These joints will be processed by investment casing and shipped to the plant. To allow for a flush skin surface, the beams will be joggled and riveted to the joints. Once the cage is formed, the window frame and spacers will be attached.

Since the safety cage is created from hat-shaped beams, special care must be taken. Since the skin will cap the cannel, corrosion inspection will be impossible. In order to correct this problem a double layer of sealant will be used, and each hat-channel will be filled with polyurethane. The use of the polyurethane will act as a protective layer for the sealant during construction. A side benefit of the polyurethane core is that is will increase the moment of inertia of the beams while absorbing vibration and noise. Once the this process is completed the skin of the aircraft will be flat wrapped and riveted into place.

### 5.2 Manufacturing of the Mid-Section and Empennage

The empennage and mid-section were handled as separate parts due to a drastic change in geometry. The construction of the two parts are very similar with the exception of the geometry and the cutouts.

#### 5.2.1 The Midsection and Empennage Formers

The Empennage consists of six formers and the mid-section consists of two formers. Each of these formers can be seen in drawing S94-1A-301-1B. The material used for these formers is 0.020" thick 2024-T3 aluminum. The process used to manufacture these formers is as follows:

1. Each former is blanked from sheet stock.
2. Each former is then brake formed.
3. The holes for rivets and bolts are drill pressed.

It should be noted that each former has a different size, shape and use. Therefore, hole positions vary with each former.

#### 5.2.2 The Stringers in the Mid-Section and Empennage

The stringers pass through both the mid-section and the empennage of the aircraft. The stringers are made of 2024-T3 aluminum however, the thickness varies for each section. The thickness is 0.040" and 0.020" for the mid-section and empennage, respectively. The process of brake forming is used in manufacturing each stringer. The stringers are passed through holes in the formers. These holes were made in the blanking process.

#### 5.2.3 Doublers in the Mid-Section and Empennage

Doublers are used in areas where reinforcements are needed to prevent tear out, shear out, and bearing stress failures. The process used to manufacture these doublers is as follows:

1. Each doubler is blanked from sheet stock.
2. Each doubler is then contour rolled (if needed).
3. The holes for rivets and bolts are drill pressed.

The doubler thickness varies with application however, all doublers are made from 2024-T3 aluminum.

### 5.2.4 Skin Surrounding the Mid-Section and Empennage

The skin of the aircraft is 0.020" thick 2024-T3 aluminum. The skin is flat wrapped and riveted around both the mid-section and the empennage. The skin must first be blank formed in order to cut the skin to shape, and to allow holes for cutouts. These cutouts are for the windows and various access panels.. The seams between skin sections must be sealed in order to prevent water intrusion of any kind.

### 5.2.5 Nuts, Bolts, Washers, Rivets, and Other Connectors in the Mid-Section and Empennage

All nuts, bolts, washers, rivets, and other connectors will be purchased from the appropriate manufactures.

### 5.2.6 Assembly of the Mid-Section and Empennage

In order to ensure ease of assembly, the aircraft must be assembled in a logical manor. The order of assembly for both the mid-section and the empennage is as follows:

1. The doublers should be attached to formers as needed.
2. The stringers and formers will be connected using assembly clips. This is done to create a frame to rap the skin around.
3. The mechanisms and mountings that are connected to the frame should be connected now (for the electrical and control system).
4. The skin should be flat rapped and riveted to the frame.
5. The midsection and empennage should be connected together.
6. The vertical and horizontal tail can now be attached (holes and connection points are provided).
7. Flashings are riveted to the skin between horizontal tail, vertical tail and the empennage.
8. Mid-Section and Tail are ready for connection to the tail.

## 5.3 Manufacturing of Elevator and Ailerons Controls

The pulleys, square tubing, circular tubing, cable, nuts , bolts, ball bearings, and the push-pull rods are all vendor supplied. The bracket for the vertical circular shaft and the pulleys will be blanked to get the cutouts and then brake formed to obtain the shape desired. (See Drawing S94-1A-401-1B). The elevator bell crank and the aileron bell cranks will be blanked. The stops on either side of the square collar will be obtained from contour rolling. The square tube will be welded to the circular tubing and then it will be crimped around it. The rod connecting the elevators will be welded at the hinge. The bell crank will then be attached to the rod using a clamp and bolt.

The panel in the passenger compartment will be easily removed to allow access to most of the pulleys and cables running through the tail cone. The pulleys run side by side for the elevator. The aileron controls can be easily accessed through the access panels in the wing. The stick assembly can be maintained by looking behind the dash. Fafnir Aircraft Ball Bearings were used because they are corrosion resistant. The exposed surfaces are Cadmium plated, they use the Fafnir Plyo-Seal to insure retention of lubricant and to keep out moisture and debris. This meets the requirements for sand and dust as well as the rain requirement. The seal also helps in the requirement for fog and salt. These are the requirements per FAR Part 23.

### 5.4 Manufacture of Rudder Controls

Aluminum castings are used in the manufacture of most of the components within this system. The casting consists of 2024-T3 alloy. The pedal, actuated cranks, and center crank are manufactured using 2024-T3 aluminum plate which will be first blanked for holes and then pressed formed if needed. The Y connectors, actuator crank, ball bearings, push-pull rods, and the end rod connectors are also made out of 2024-T3 aluminum alloy. All other components within the rudder and braking system are aircraft approved stock items.

Both the rudder and braking system are easily accessible, including the pulleys, which are attached to the safety cage and the empennage. The rudder and brake system will be installed after the floor has been attached to the safety cage.

### 5.5 Manufacture of Dashboard

The dashboard will be a quarter of an inch thick made out of 2024-T3 aluminum sheet plate. The instruments proposed for this dashboard design have been selected from Aircraft Spruce & Specialty Company Catalog. The cover plate and each instrument can easily be removed for replacement or repair.

## 6. Cost Summary

### 6.1 Cost Summary of the Safety Cage

To help keep cost low in the fabrication of the safety cage, different fabrication processes where thought of during the design of the safety cage:

1. Common size of the hat-shaped beams where used. This decision to use common parts will allow for shipment of large quantity of interchangeable supplies.
2. Preformed joints will be used. Using this technique will allow for a faster fabrication, while keeping the quality of the work high.
3. The preformed joints will be investment cased. Compared to different forging and casting, it was shown that the ratio of high standard of accuracy to cost of investment casting was cheaper .

## 6.2 Cost Summary for the Mid-Section and Empennage

The following measures were taken in order to reduce the cost of manufacture:

1. Flat rapping was used as much as possible. Further, sheets of standard size and thickness were used.
2. All fasteners and connectors were of standard sizes and shapes. Thus, they could be purchased from the proper manufactures.
3. The cheapest manufacturing processes that accomplished the same net result was always chosen. Rolling and forming the various shapes from sheet metal is also more realistic than machining a piece from a solid block of aluminum.

## 6.3 Cost Summary of Elevator and Aileron Control System

Most of the parts needed for the elevator and aileron control systems were less expensive to purchase than to manufacture. The pulleys, circular shafts, square shafts, push-pull rods, cables , ball bearings, nuts and bolts were all vendor supplied. The following table lists the prices of those listed in Aircraft Spruce and Specialty Company.

**Table 6.1: Summary of Purchase Costs for Elevator and Aileron Control Systems**

| Part | Cost |
|---|---|
| Pulleys (23) | $320.62 |
| Circular Tube (2.3 ft.) | $ 6.74 |
| Square Tube (1 ft.) | $ 2.98 |
| Push-Pull (2) | $ 35.24 |
| Circular tube (8.4 ft.) | $ 35.24 |
| Cable | $ 23.94 |
| Ball Bearings (20) | $397.6 |
| Bolts (50) | $ 8.00 |
| Total | $800.52 |

These figures are based on the purchase price of one item. If ordered in mass quantities there is usually a 20-30% discount. Assuming a 25% discount this would take the price down to $600.39.

For the other pieces, it is less expensive to manufacture them than to do a special order at extra cost. They are obtained in standard stock and then manufactured in the way indicated previously.

## 6.4 Cost Summary of the Rudder Control System

The following measures were taken in order to reduce the cost of manufacture:

1. All fasteners and connectors were of standard sizes and shapes. Thus, they could be purchased from the proper manufactures.
2. Whenever possible, preexisting parts of the rudder control system were used. Thus, they could be purchased from the proper manufactures.
3. The cheapest manufacturing processes that accomplished the same net result was always chosen (See Manufacturing Section).

## 6.5 Cost Summary of the Dashboard and Equipment

The total estimated price is approximately $11,500. This price includes $300 for the remaining parts not listed here. The price for each of the components are obtained from Aircraft Spruce & Specialty Company catalog.

**Table 6.2: Major Dashboard items and prices**

| Item number | Item description | Price per item ($) |
|---|---|---|
| 1 | Hour meter | 38.95 |
| 2 | Turn bank indicator with 2" venturi, hoses, fittings and instrument screws | 283.00 |
| 3 | Vertical speed indicator | 38.95 |
| 4 | Airspeed indicator | 149.50 |
| 5 | Directional Gyro Tru-Flight Horizon | 324.00 |
| 6 | Altimeter 0-10000 ft | 132.80 |
| 7 | VOR's | 286.75 |
| 8 | Dual EGT-CHT | 61.60 |
| 9 | Compass | 74.00 |
| 10 | Tachometer 2500 cruise RPM | 138.75 |
| 11 | Oil Pressure 0-100 psi | 20.50 |
| 12 | Dual fuel level | 61.60 |
| 13 | 2 Fuel pressure 0-30 psi | 28.75 |
| 14 | Suction gage | 69.55 |
| 15 | Oil temperature with adapter 100-259$^{\circ}$ F | 30.00 |
| 16 | Ammeter/Voltmeter (dual) 6-16 V/0-60 A | 85.85 |
| 17 | 2 Digital ADF Radio | 1985.00 |
| 18 | Audio Control Panel with marker beacon receiver/lights | 798.00 |
| 19 | Digital Nav/Com radio | 1585.00 |
| 20 | Transponder with installation kit and antenna | 990.00 |
| 21 | Autopilot Control Unit | 2795.00 |

## 7. Weight Summary

To find the weight of the different components associated with this design of the Triton, two techniques were used. The first technique was to refer to the Aircraft Spruce & Specialty Company aircraft supplies catalog. The second method was to use the volume rule:

$$W = V\rho$$

where:
W = Weight
V = Volume
ρ = Density

The following table shows the calculated weights for the parts associated with this design of the Triton:

Table 7.1: Weight Table

| Parts No. (Dwg. No.) | Title | Number used | Weight per Part (lbs) | Total Weight (lbs) |
|---|---|---|---|---|
| 1 (201) | Hat Shaped Beams | 27 | varies according to length | 36.5 |
| 2 (201) | Square Tube Beams | 4 | varies according to length | 5.3 |
| 3 (201) | Investment Cast Joints | 20 | varies according to length | 32.2 |
| 4 (201) | Rivet AD-AN430-DD-3-4 | 3650 | 0.00122 | 0.445 |
| 5 (201) | Rivet AD-AN430-DD-4-6 | 1376 | 0.00122 | 0.176 |
| 1 (401) | Pulley | 23 | 0.35 | 8.0 |
| 2 (401) | Pulley Mounts | 23 | 0.2 | 4.5 |
| 11 (401) | Round Tubing | 8.4 ft | 0.3244 lb/ft | 2.7 |
| 4 (401) | Bracket for Vertical Tube | 1 | 0.6 | 0.6 |
| 5 (401) | Elevator Bell crank | 1 | 1.0 | 1.8 |
| 6 (401) | Square Tube | 1 | 0.3 | 0.3 |
| 7 (401) | Ball Bearings | 20 | 0.01 | 0.2 |
| 8 (401) | Aileron Bell crank | 2 | 0.9 | 1.8 |
| 9 (401) | Push-pull Rod | 1 ft | 3.76 lb/ft | 3.76 |
| 10 (401) | Aileron Stop | 4 | 0.4 | 1.6 |
| 12 (401) | Rod Connection Elevators | 1 ft | 3.36 lb/ft | 3.76 |
| 1, 4, 15 (402) | Push-pull Rod | 6 | varies according to length | 6.6 |
| 3 (402) | Center Crank | 1 | 0.303 | 0.303 |
| N/A | Center Crank Mount | 1 | 1.212 | 1.212 |
| 5 (402), 2 (403) | Actuated Crank Mount | 2 | 0.808 | 1.616 |
| N/A | Actuated Crank | 4 | 1.515 | 6.06 |

| Parts No. (Dwg. No.) | Title | Number used | Weight per Part (lbs) | Total Weight (lbs) |
|---|---|---|---|---|
| 8 (402) | Y Connectors | 4 | 0.202 | 0.808 |
| 11 (402) | Pedal Mounts | 8 | 0.202 | 1.616 |
| 13 (402) | Rudder Pedals | 4 | 3.1815 | 12.726 |
| 7 (403) | Bearing Balls | 8 | 0.825 | 6.6 |
| 3 (403) | Rudder Mount | 8 | 0.202 | 1.616 |
| 1 (403) | Front Wheel Crank | 1 | 2.424 | 2.424 |
| N/A | Tail Crank | 1 | 2.424 | 2.424 |
| 1 (301) | Skin | N/A | N/A | 21.14 |
| 2 (301) | Mid-Section Former | 1 | N/A | 0.917 |
| 3 (301) | Mid-Section Former | 1 | N/A | 0.450 |
| 4 (301) | Empennage Former | 1 | N/A | 0.382 |
| 5 (301) | Empennage Former | 1 | N/A | 0.317 |
| 6 (301) | Empennage Former | 1 | N/A | 0.250 |
| 7 (301) | Empennage Former | 1 | N/A | 0.217 |
| 8 (301) | Empennage Former | 1 | N/A | 0.161 |
| 11 (301) | Washer | 11 | 0.0012 | 0.013 |
| 12 (301) | Bolts AN8DD6 | 61 | 0.019 | 1.17 |
| 13 (301) | Rivets MS20430DD-2-3 | 1966 | 0.00012 | 0.24 |
| 14 (301) | Nut AN365-D820 | 61 | 0.0107 | 0.65 |
| 15 (301) | Washer AN960-D820 | 122 | 0.0012 | 0.144 |
| 16 (301) | Bolt AN4DD4 | 48 | 0.0129 | 0.6 |
| 17 (301) | Nut AN3150D4 | 48 | 0.0065 | 0.31 |
| 18 (301) | Doubler | 3 | 0.5 | 0.15 |
| 19 (301) | Eye Bolt | 1 | 0.05 | 0.05 |
| 20 (301) | Rivet MS20430DD-3-4 | 50 | 0.0012 | 0.06 |
| 21 (301) | Angle Bracket | 12 | 0.017 | 0.2 |
| 22 (301) | Nut AN315-D6 | 1 | 0.005 | 0.005 |
| 23 (301) | Rivet MS20430DD-3-5 | 92 | 0.00092 | 0.085 |
| 1 through 40 (501 ) | Flight Instruments | See Cost Table for instruments | varies according to instrument | 40 |

| Weight from Previous Pages | 215.16 |
|---|---|
| **Weights from previous design team** | |
| Wing | 170.0 |
| Horizontal Tail | 14.2 |
| Vertical Tail | 8.9 |
| Main Gear | 114.2 |
| Nose Gear | 47.2 |
| Engine installations | 229.0 |
| Fuel System | 23.3 |
| Electrical System | 70.3 |
| Furnishings | 26.4 |
| Total Aircraft Weight | 918.66 |

**Note:** The weight calculation for this design of the Triton II was 4 lbs. heavier when compared to previous design reports.

## 8. Conclusions

For detail design of the Triton II (1B) many stipulations were made. These stipulations were requirements and conditions stated in the statement of work and the FAR Part 23. The first condition to be met was the operational temperature range of the aircraft between -40°F to +122°F. Since the aircraft was previously designed to meet this temperature range, the design team assumed all previous work was correct.

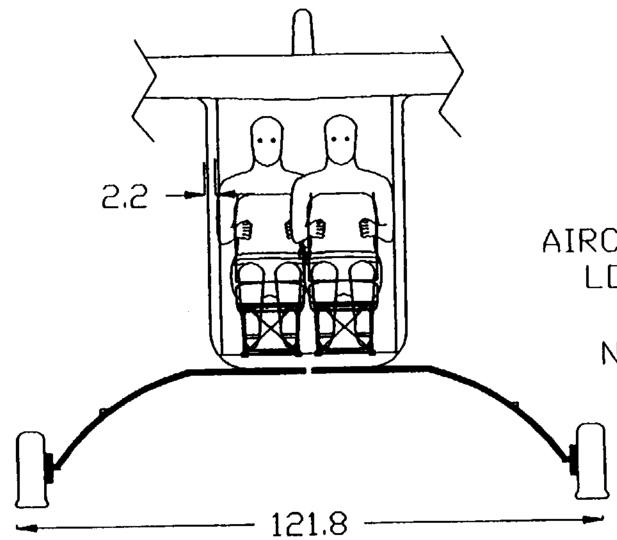
A second temperature requirement was ice present at -40°F. From a study of parts associated with the Triton, it was noticed that the control system is affected by this condition. To account for ice, the control system cables and pulleys were located 1.75 inches above the bottom the aircraft. This is to ensure that if water collects and freezes that it will not interfere with the control system.

The third temperature requirement dealt with 100 percent humidity at +95°F. In this condition the instruments were affected. Since the instruments are sensitive to heat and humidity, a cooling fan will be mounted on the backside of the instrument panel.

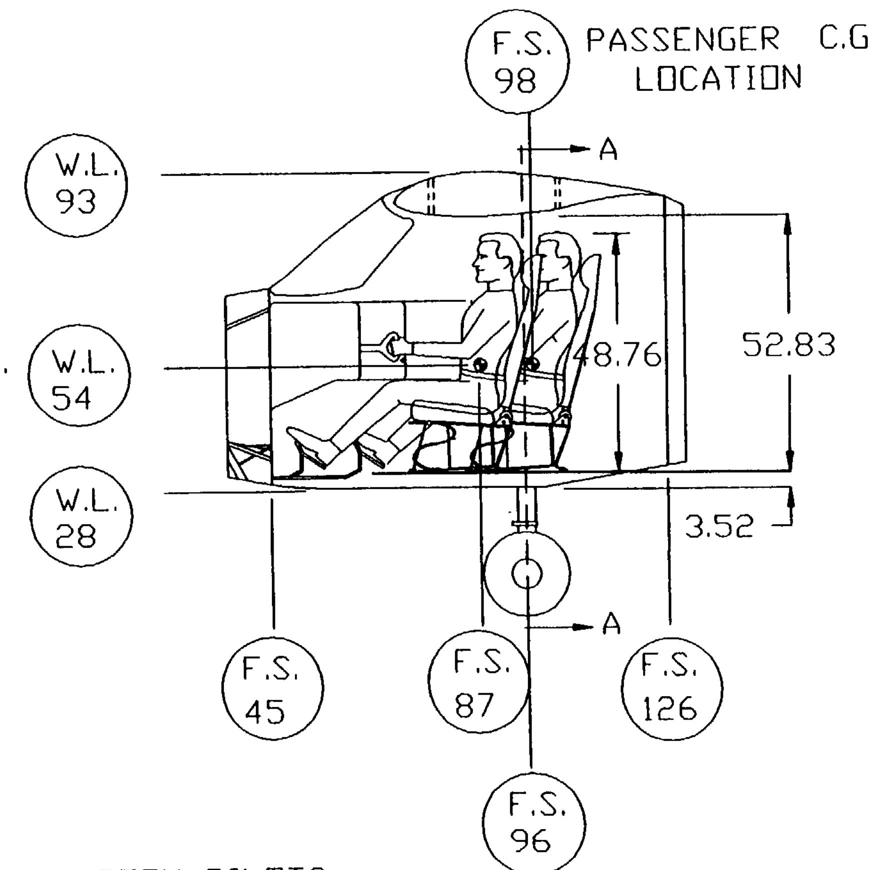
A forth condition deals with the atmospheric environment in which the aircraft will be operating. One of these environmental condition deals with all external surfaces and moving parts' ability to withstand 0.041 grams per cubic foot of sand or dust of an average size of 150 microns. To meet this requirement, all pulley bearings will be sealed. A rain fall of 4.0 inches per hour at a wind velocity of 150 miles per hour was the next condition. To ensure that water infiltration does not occur, all skin joints will be sealed. Due to salt and water in the air, corrosion problems did exist. To protect metals from corrosion, many different techniques were used. The skin will be painted with a primer and a final coat of paint, the cage will have a double layer of sealant with a polystyrene core. Inspection doors will be provided to inspect the control cables. The final environmental condition dealt with 10.0 inches of wet snow. From the study of this load it was proven that this load, would not exceed any fight loading.

The last stipulation stated that a service ceiling of 14,000 feet must be reached. Because the Triton was previously design to achieve an altitude of 14,000 feet, the only area of concern will be with the pilot. Since this aircraft is non-pressurized, the pilot will have to rely on an oxygen tank if an altitude of 14,000 feet is desired.

Many different design considerations were implemented in the design of the Triton II. Among them was a safety cage for added safety during a crash, and the design of a control system that will allow future pilots to transition from a traditional cable control system to a fly by wire system. It is hopeful that these new designs will be implemented in future aircraft designs.

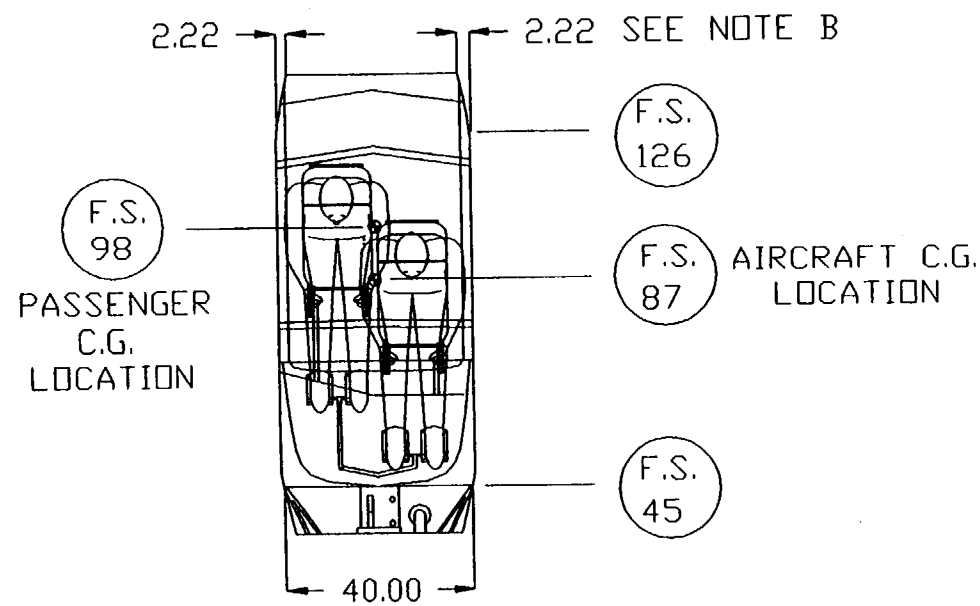


SECTION A-A
STATION 96




NOTE A: INCLUDES BOTH PILOTS

| | |
|---|---|
| DIMENSION TOLERANCES UNLESS OTHERWISE SPECIFIED<br>DECIMAL<br>.XX ± .01<br>.XXX ± .001<br>ANGULAR<br>± 0.5° | EMBRY-RIDDLE AERONAUTICAL UNIVERSITY<br>DAYTONA BEACH, FL<br>SIZE: A · DATE: 4/27/94 · SCALE: 1=40 · DRAWN BY: J. NEHER<br>TITLE: SPATIAL REQUIREMENTS SPECIFICATIONS<br>DRAWING NO.: S94-1A-102-1B · SHEET: 1 OF 2 |




NOTE B: MINIMUM REQUIRED WALL THICKNESS

| | | | | |
|---|---|---|---|---|
| DIMENSION TOLERANCES UNLESS OTHERWISE SPECIFIED | EMBRY-RIDDLE AERONAUTICAL UNIVERSITY DAYTONA BEACH, FL | | | |
| DECIMAL .XX ± .01 .XXX ± .001 | SIZE A | DATE 4/27/94 | SCALE 1=40 | DRAWN BY J. NEHER |
| ANGULAR ± 0.5° | TITLE SPATIAL REQUIREMENTS SPECIFICATIONS | | | |
| | DRAWING NO. S94-1A-102-1B | | | SHEET 2 OF 2 |

FOLDOUT FRAME /

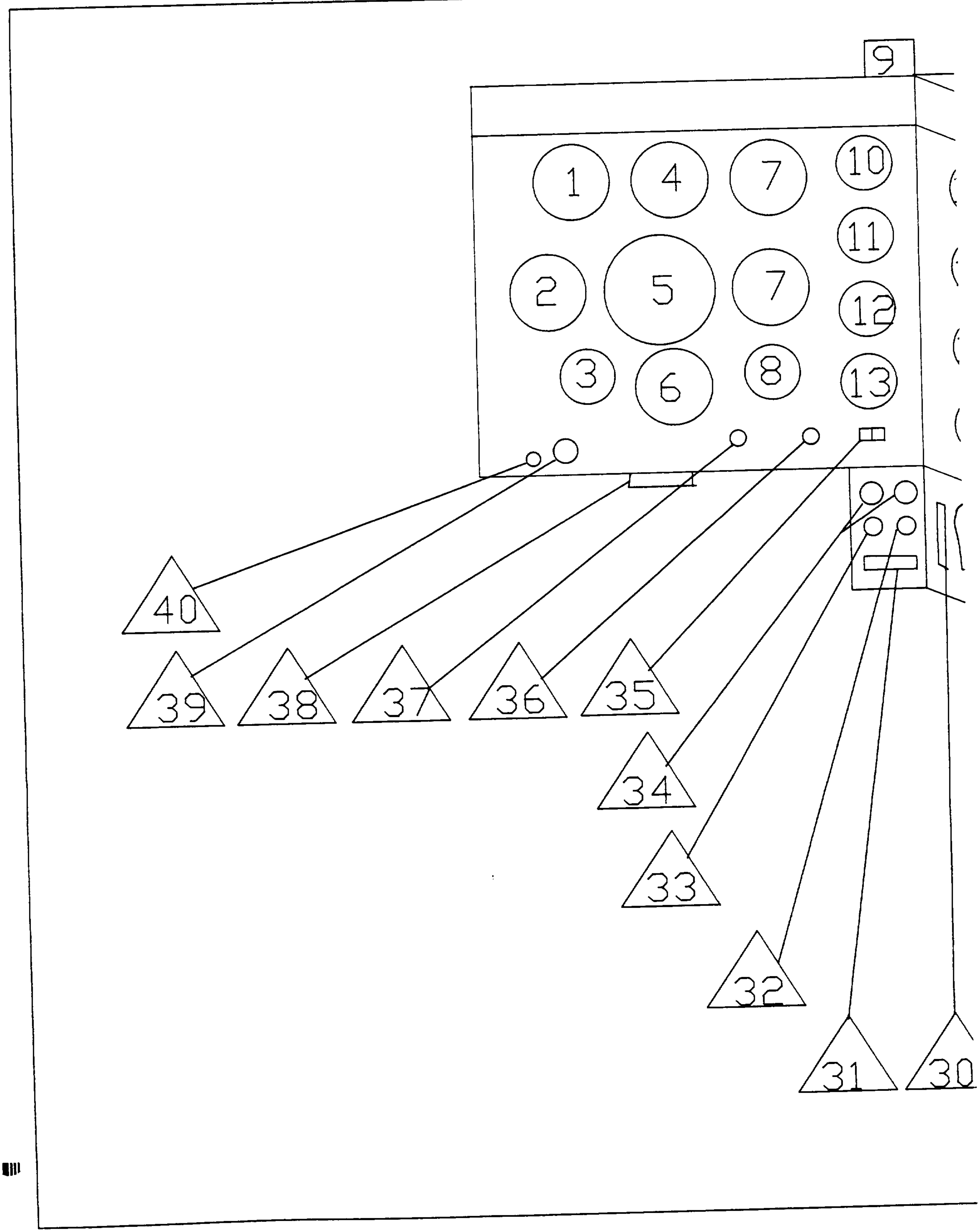
| | | | |
|---|---|---|---|
| 21 | 1 | AUTOPILOT CONTROL UNIT | P/N 11-20000 |
| 20 | 1 | TRANSPONDER | KT-76A |
| 19 | 1 | DIGITAL NAV/COM RADIO | KX-125 |
| 18 | 1 | AUDIO CONTROL PANEL | P/N 11-19905 |
| 17 | 2 | DIGITAL ADF RADIO | KING KR 86 |
| 16 | 1 | AMMETER/VOLTMETER | P/N 2DA10-18 |
| 15 | 1 | OIL TEMP. GAGE | 10-11700 |
| 14 | 1 | SICTOPM GAGE | P/N 10-01000 |
| 13 | 2 | FUEL PRESSURE GAGE | P/N 100171 |
| 12 | 1 | DUAL FUEL LEVEL GAGE | P/N 2DA4 |
| 11 | 1 | OIL PRESSURE GAGE | P/N 10-22302 |
| 10 | 1 | TACHOMETER | 10-24625 |
| 9 | 1 | COMPASS | C2300 |
| 8 | 1 | DUAL EGT-CHT | P/N 2DA1 |
| 7 | 1 | VOR | P/N 10-24560-14- |
| 6 | 1 | ALTIMETER | P/N 10-05110 |
| 5 | 1 | DIRECTIONAL GYRO | P/N 10-00100 |
| 4 | 1 | AIRSPEED INDICATOR | 10-02200 |
| 3 | 1 | VER. SPEED INDICATOR | P/N 10-05205 |
| 2 | 1 | TURN BANK INDICATOR | P/N AN5820-1 |
| 1 | 1 | HOUR METERS | P/N 56457-3 |
| ITEM | QTY. | DESCRIPTION | PART NUMBER |

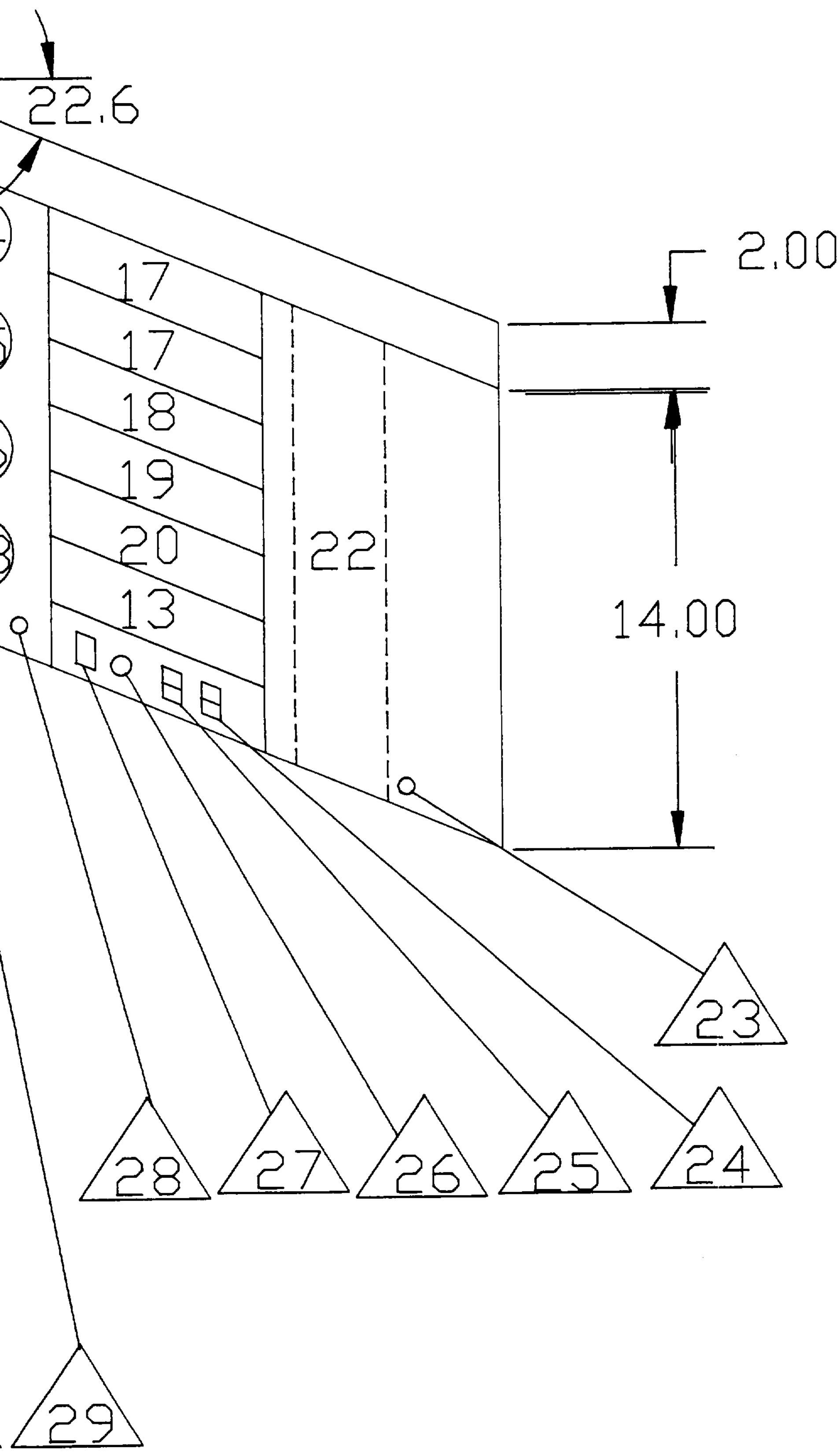
FOLDOUT FRAME 2

| ITEM | QTY. | DESCRIPTION |
|---|---|---|
| | | |
| | | |
| 40 | 1 | PILOT HEADSET JACK |
| 39 | 1 | PRIMER |
| 38 | 1 | PARKING BRAKE HANDLE |
| 37 | 1 | CARBURATOR HEAT CONTROL |
| 36 | 1 | MIXTURE CONTROL |
| 35 | 1 | FUEL SELECTOR VALVE SWITCH |
| 34 | 1 | AIR CONDITIONING CONTROL |
| 33 | 1 | CABIN HEAT CONTROL |
| 32 | 1 | CABIN AIR CONTROL |
| 31 | 1 | RUDDER TRIM CONTROL LEVER |
| 30 | 1 | ELEVATOR TRIM CONTROL WHEEL |
| 29 | 1 | HAND-HELD MICROPHONE |
| 28 | 1 | STATIC PRESSURE ALTERNATE SOURCE VALVE |
| 27 | 1 | WING FLAP SWITCH AND POSITION INDICATOR |
| 26 | 1 | IGNITION SWICH |
| 25 | 1 | MASTER SWITCH |
| 24 | 1 | AVIONICS POWER SWITCH |
| 23 | 1 | INSTRUCTOR HEADSET JACK |
| 22 | 1 | FUSE LOCATION |

| | | | | |
|---|---|---|---|---|
| DIMENSION TOLERANCES UNLESS OTHERWISE SPECIFIED | EMBRY-RIDDLE AERONAUTICAL UNIVERSITY DAYTONA BEACH, FL | | | |
| DECIMAL<br>.XX ± .01<br>.XXX ± .001 | SIZE B | DATE 4/24/94 | SCALE 1 = 5 | DRAWN BY RICHARD RUDOLPH |
| ANGULAR<br>± 0.5° | TITLE DASHBOARD CONFIGURATION | | | |
| | DRAWING NO. S94-1A-501-1B | | | SHEET 1 OF 2 |

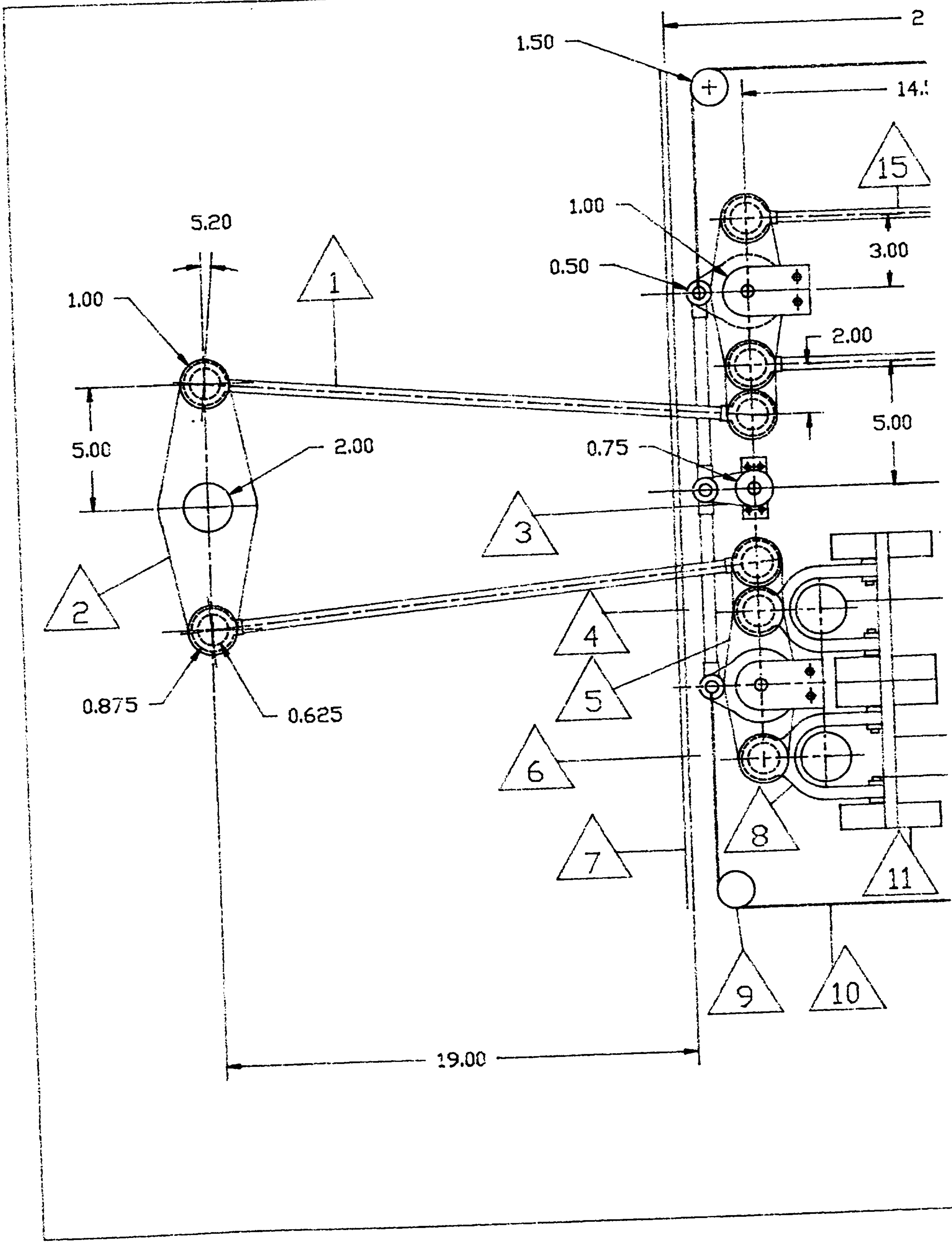
FOLDOUT FRAME 1

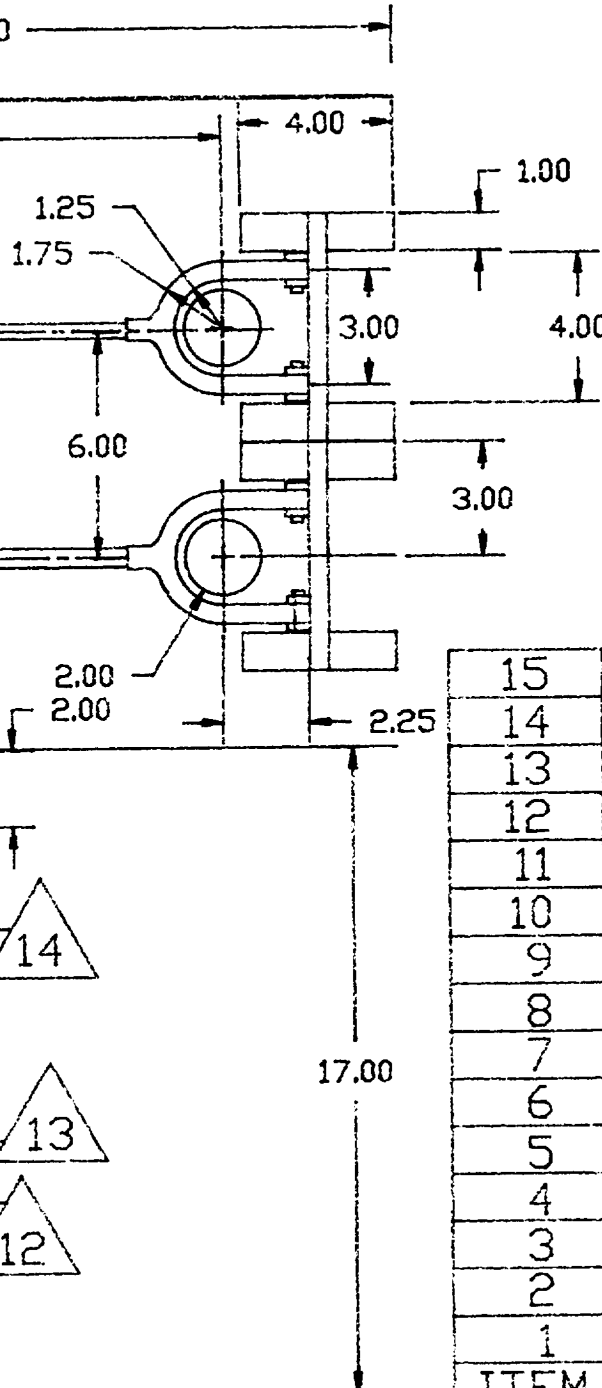





| DATE | BY | DWG. NO. | SHT. |
|---|---|---|---|
| 4/24/94 | R. RUDOLPH | S94-1A-501-1B | 2 OF 2 |

[redacted]LDOUT FRAME 1.






| ITEM | QTY. | DESCRIPTION | SIZE OR PART |
|---|---|---|---|
| 15 | 2 | PUSH-PULL RODS | 2024-T3 |
| 14 | 4 | BRAKE CYL. | P/N 06-11000 |
| 13 | 4 | RUDDER PEDALS | 2024-T3 |
| 12 | 8 | Y CON. NUTS | NAS1303 |
| 11 | 8 | PEDAL MOUNTS | 2024-T3 |
| 10 | 2 | RUDDER WIRE | 05-04800 |
| 9 | 6 | WIRE PULLEYS | MS20220-2 |
| 8 | 4 | Y CONNECTORS | 2024-T3 |
| 7 | 1 | FIRE WALL | 2024-T3 0.5′ t |
| 6 | 12 | BOLT, TYP. | NAS1308 |
| 5 | 2 | ACTUATED CRANK | 2024-T3 0.5′ t |
| 4 | 2 | PUSH-PULL RODS | 2024-T3 |
| 3 | 1 | CENTER CRANK | 2024-T3 0.5′ t |
| 2 | 1 | FRONT CRANK | 2024-T3 0.5′ t |
| 1 | 2 | PUSH-PULL RODS | 2024-T3 |

DIMENSION TOLERANCES UNLESS OTHERWISE SPECIFIED

DECIMAL

.XX ± .01
.XXX ± .001

ANGULAR

± 0.5°

EMBRY-RIDDLE AERONAUTICAL UNIVERSITY
DAYTONA BEACH, FL

| SIZE | DATE | SCALE | DRAWN BY |
|---|---|---|---|
| B | 04/21/94 | 1/5 | RICHARD RUDOLPH |

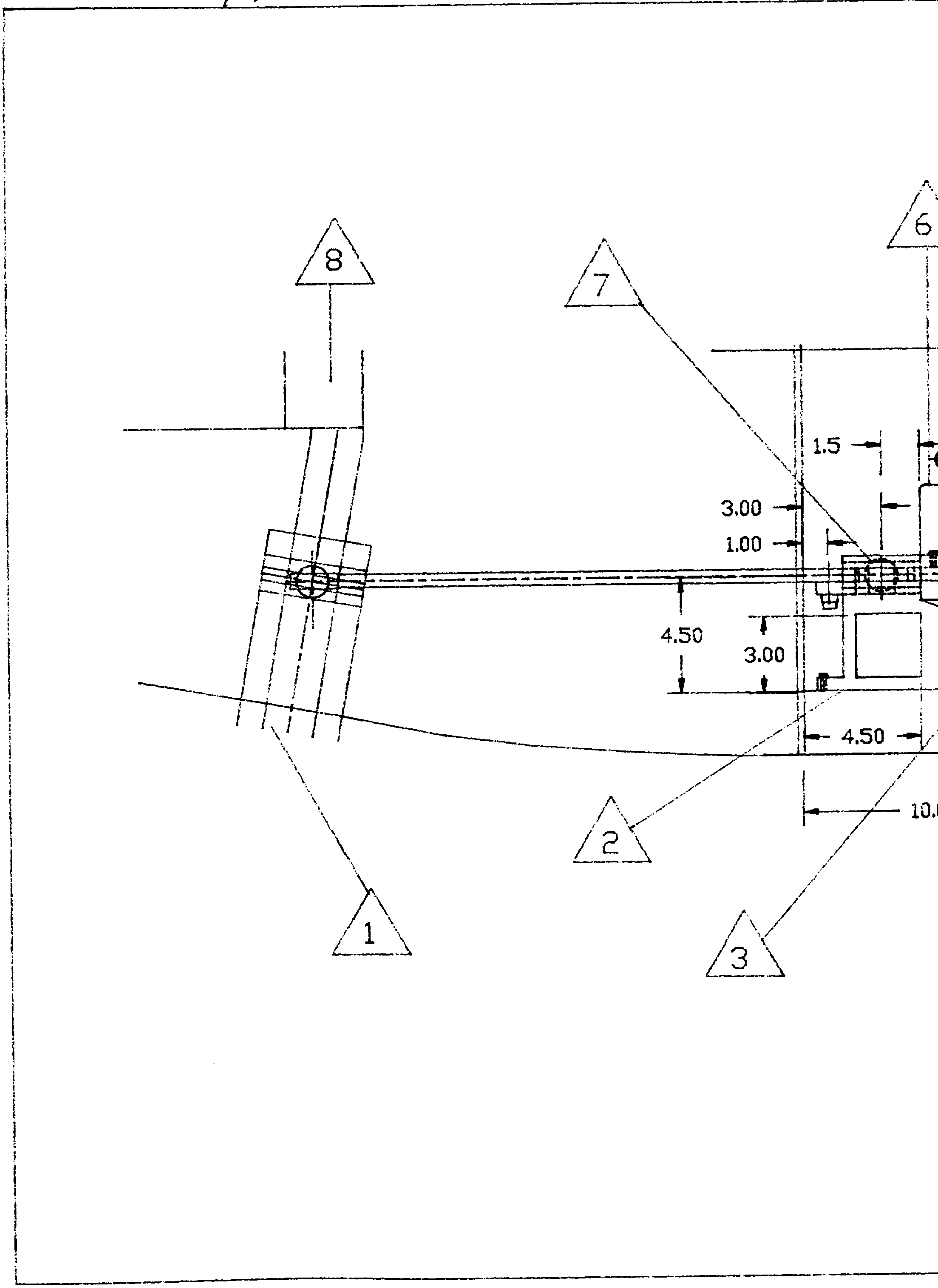
TITLE

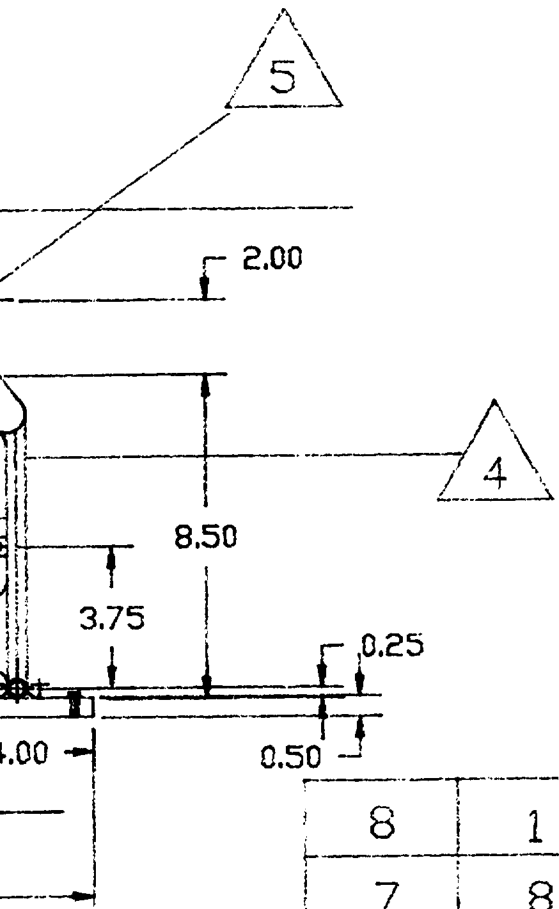
RUDDER CONTROL SYSTEM

DRAWING NO.

S94-1A-402-1B

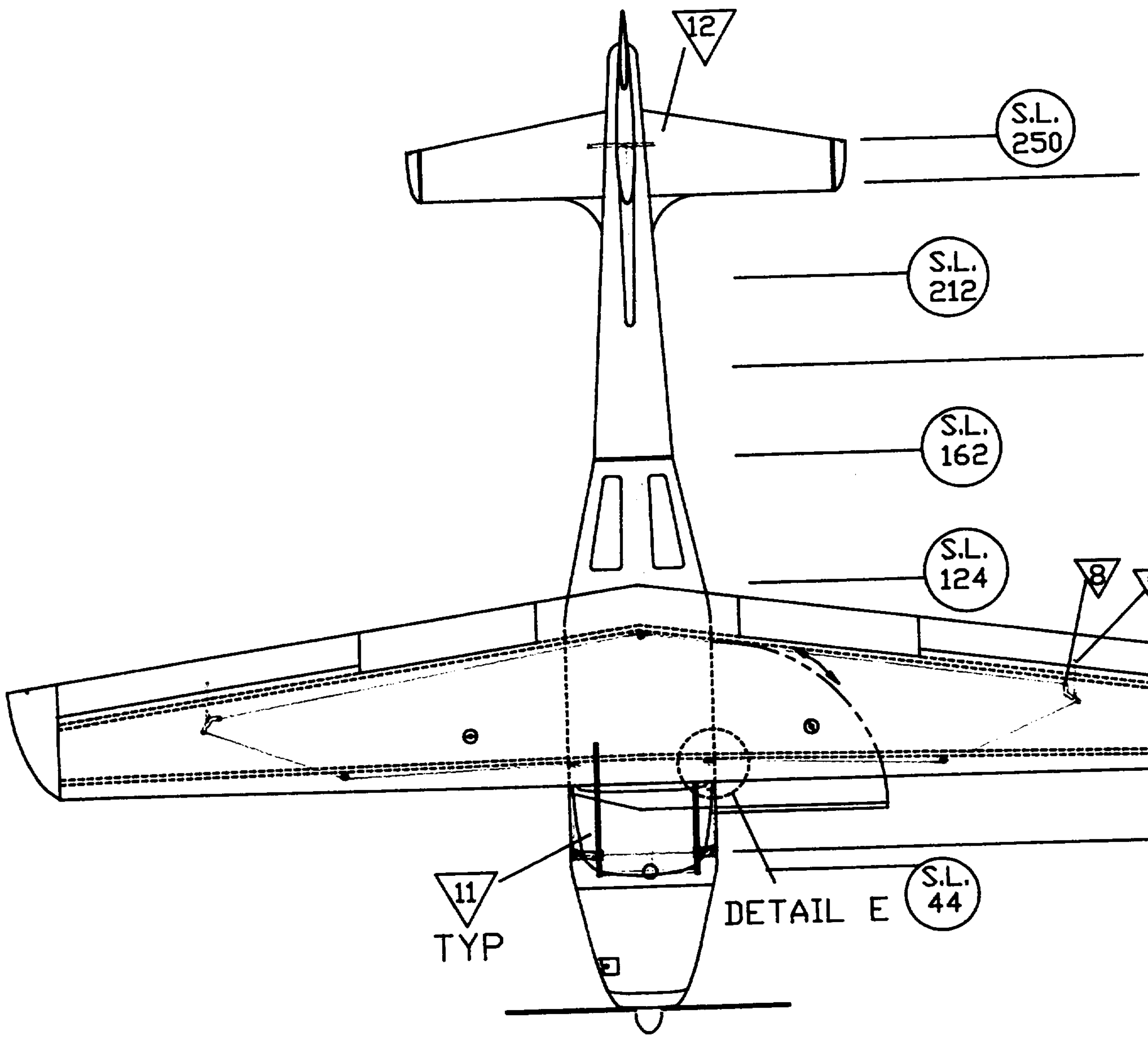
SHEET 1 OF 2


8
7
6
1.5
3.00
1.00
4.50
3.00
4.50
10.
2
1
3




| | | | |
|---|---|---|---|
| 8 | 1 | WHEEL/ENG MT. | 2024-T3 |
| 7 | 8 | BARRING BALL | 2024-T3 OD 1.25 |
| 6 | 4 | BRAKE CYL. | P/N 06-11000 |
| 5 | 4 | TOE BRAKE | 2024-T3 |
| 4 | 4 | RUDDER PEDAL | 2024-T3 |
| 3 | 8 | RUDDER MOUNTS | 2024-T3 |
| 2 | 2 | ACTUATER MOUNTS | 2024-T3 |
| 1 | 1 | FT WHEEL MOUNT | 2024-T3 |
| ITEM | QTY. | DESCRIPTION | SIZE OR PART |

| DATE | BY | DWG. NO. | SHT. |
|---|---|---|---|
| 04/21/94 | R. RUDOLPH | S94-1A-403-1B | 2 OF 2 |


12
S.L. 250
S.L. 212
S.L. 162
S.L. 124
8
11
TYP
DETAIL E
S.L. 44


| ITEM | QTY. | DESCRIPTION | SIZE OR PART NUMBER |
|---|---|---|---|
| 12 | 1 | ROD CONNECTING ELEVATORS | 03-42500 |
| 11 | 3 | CIRCULAR TUBE | 03-38300 |
| 10 | 4 | AILERON STOPS | 2024-T3, .08 THK. |
| 9 | 2 | PUSH-PULL ROD | 03-42500 |
| 8 | 2 | AILERON BELLCRANK | 2024-T3, .25 THK. |
| 7 | 28 | BALL BEARINGS | K3L3 |
| 6 | 2 | SQUARE TUBE | 03-38900 |
| 5 | 1 | ELEVATOR BELLCRANK | 2024-T3, .25 THK. |
| 4 | 1 | BRACKET FOR VERTICAL TUBE | 2024-T3, .2 THK |
| 3 | 50 | BOLT, TYP. | AN8DD6 |
| 2 | 23 | PULLEY MOUNT, TYP. | 2024-T3, .1 THK. |
| 1 | 23 | PULLEY, TYP. | MS20219-A3 |

DIMENSION TOLERANCES
UNLESS OTHERWISE SPECIFIED

DECIMAL
.XX ± .01
.XXX ± .001

ANGULAR
± 0.5°

EMBRY-RIDDLE AERONAUTICAL UNIVERSITY
DAYTONA BEACH, FL

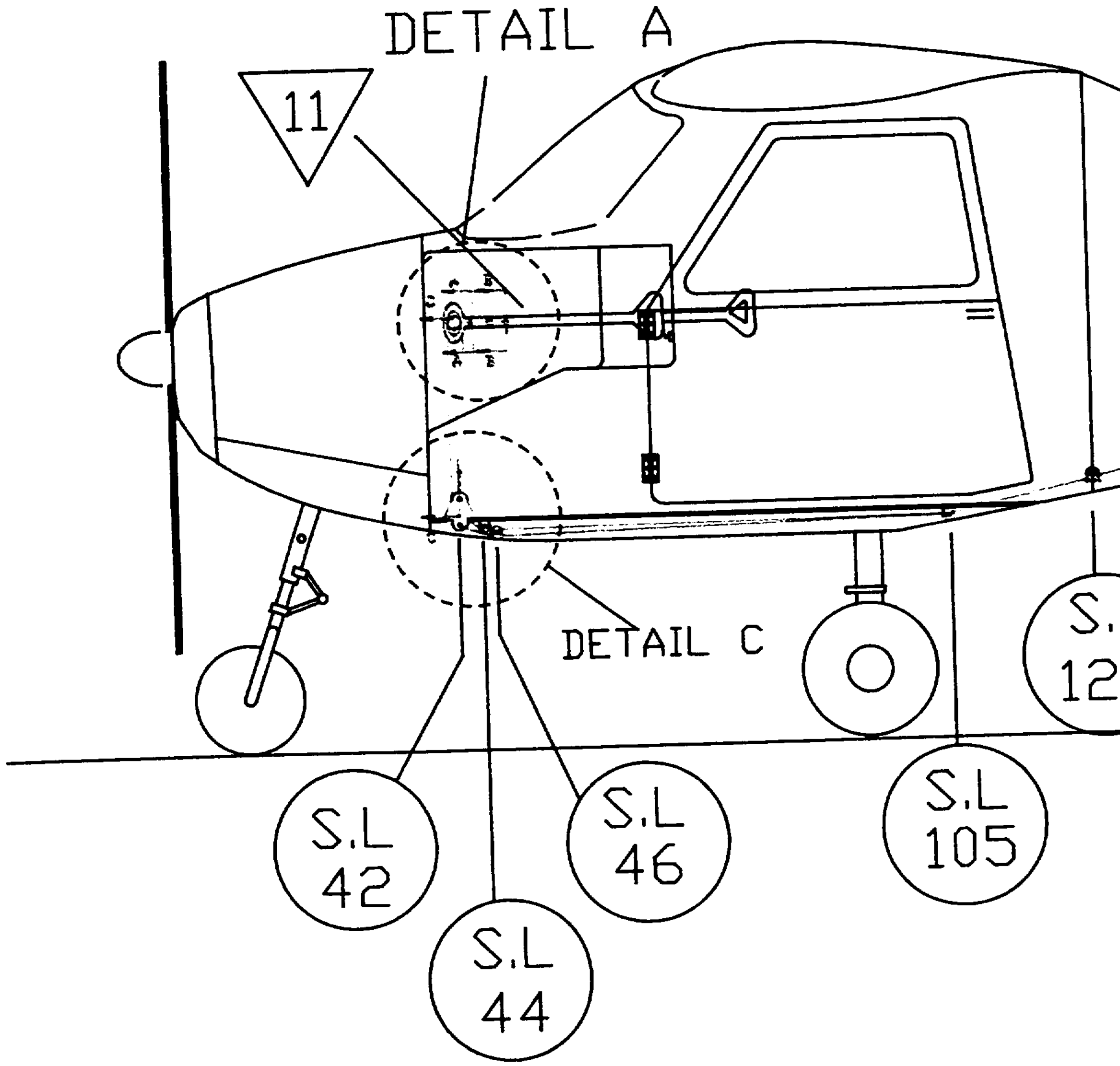
| SIZE | DATE | SCALE | DRAWN BY |
|---|---|---|---|
| B | 4/29/94 | VARIES | M. CLARK |

TITLE: CONTROLS

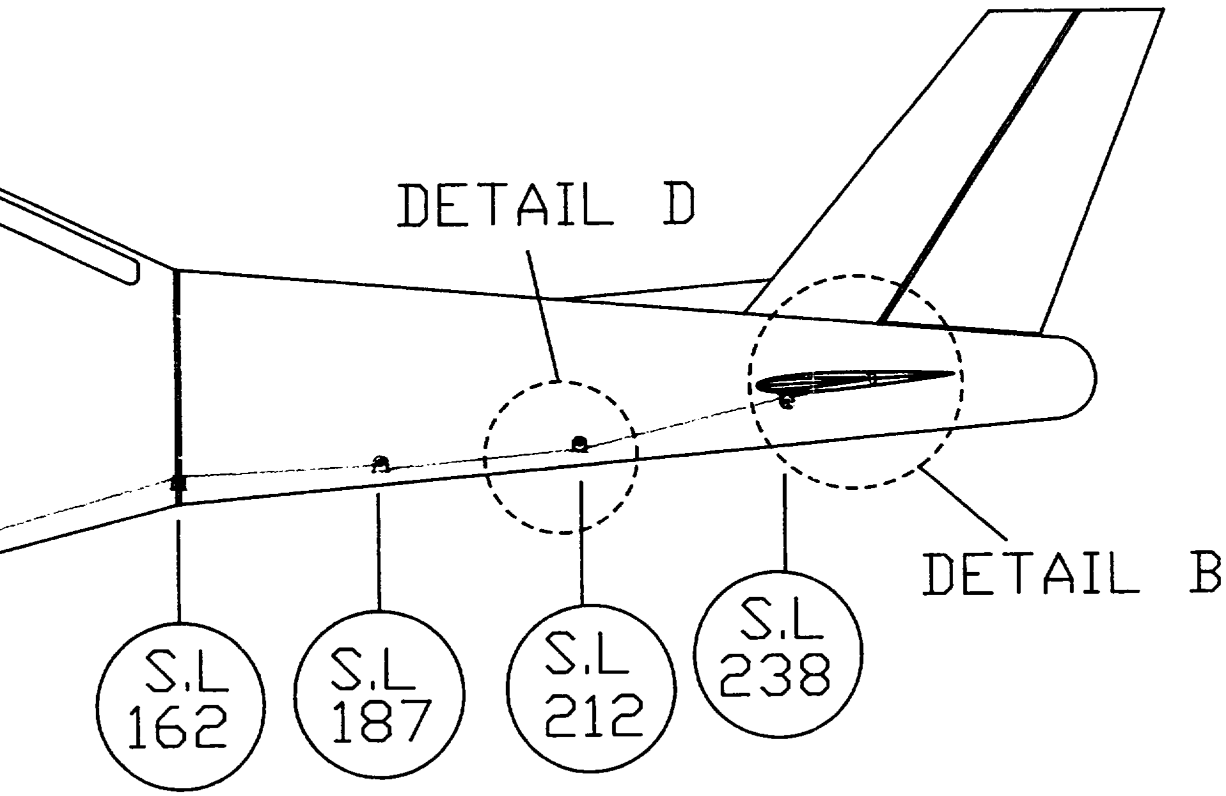
DRAWING NO. S94-1A-401-AB

SHEET 1 of 5

FOLDOUT FRAM[illegible]

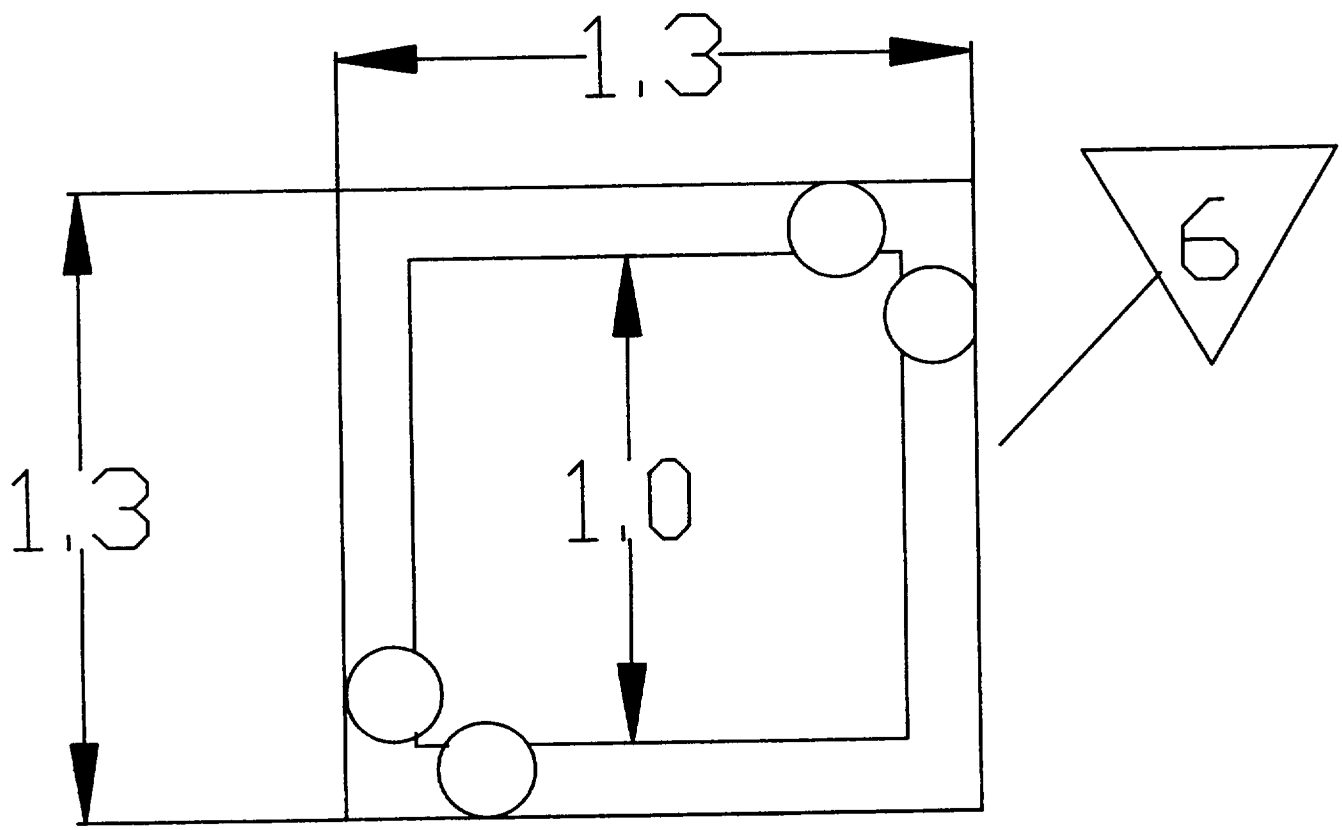


FOLDOUT 2




| DATE | BY | DWG. NO. | SHT. |
|---|---|---|---|
| 4/29/94 | M. CLARK | S94-1A-401-1B | 2 of 5 |

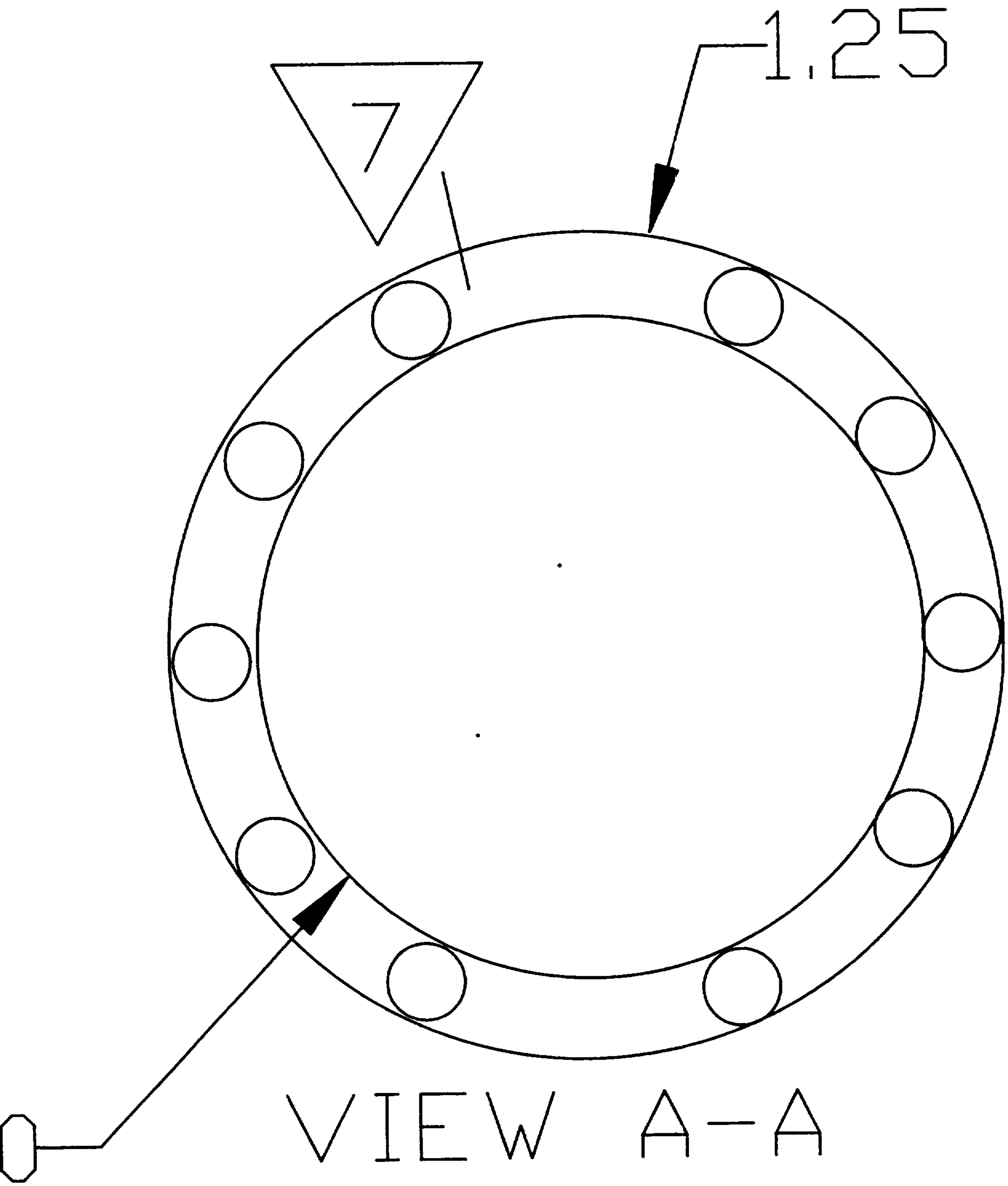
FOLDOUT FRAME /




VIEW B-B

1

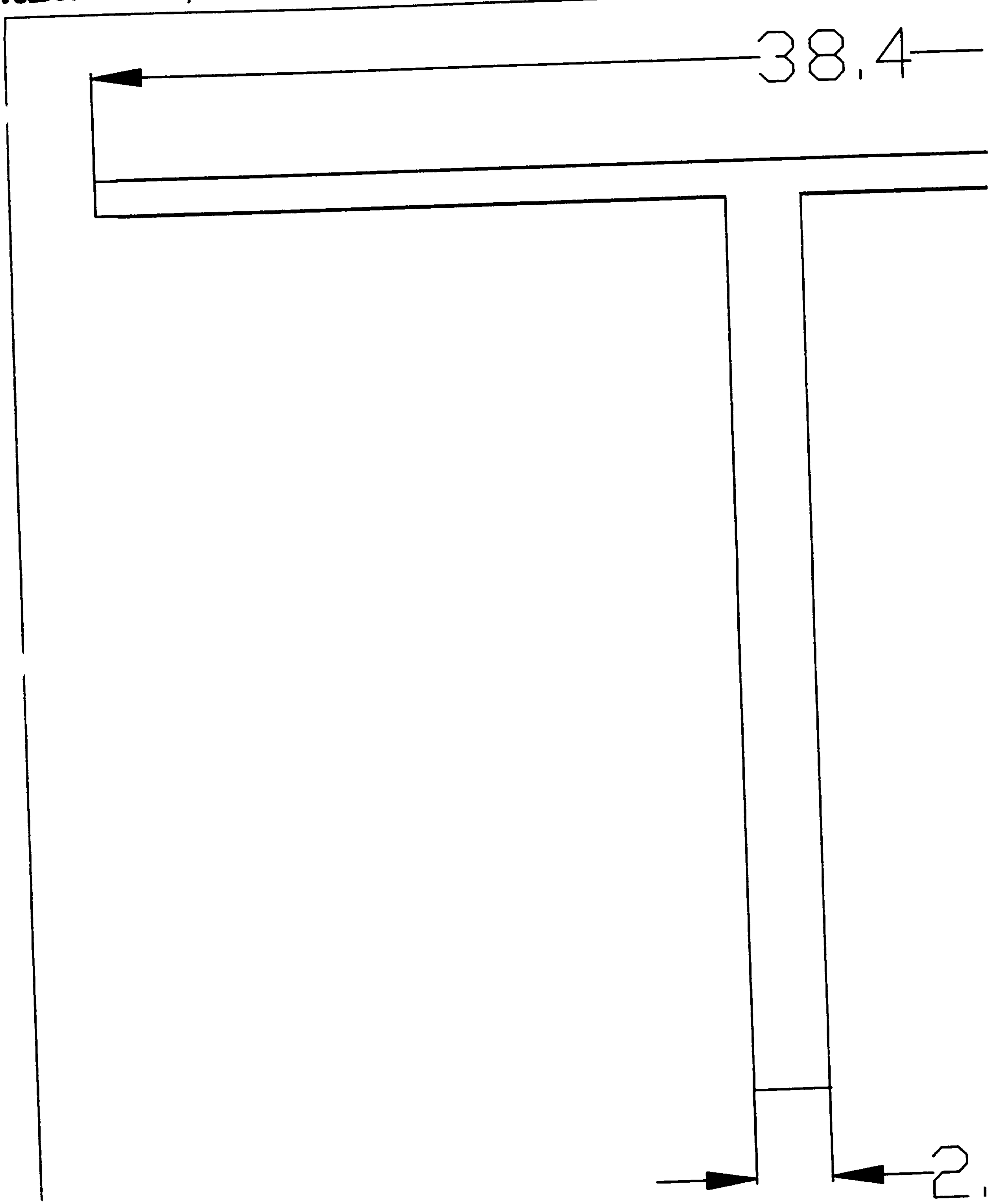
FOLDOUT FRAME 2




VIEW A-A

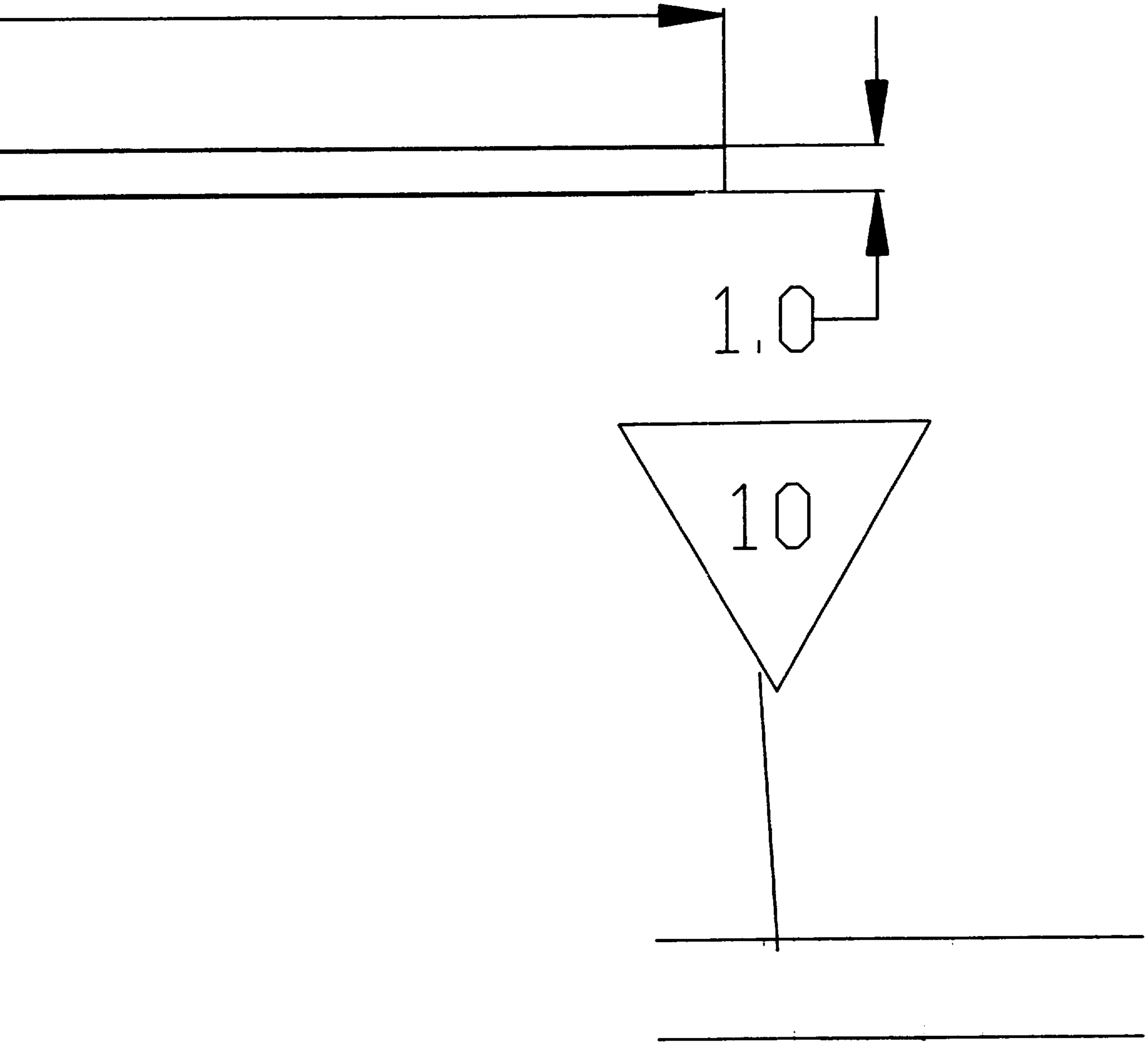
| DATE | BY | DWG. NO. | SHT. |
| --- | --- | --- | --- |
| 4/29/94 | M. CLARK | S94-1A-401-1B | 3 of 5 |

FOLDOUT FRAME /




VIEW C-C

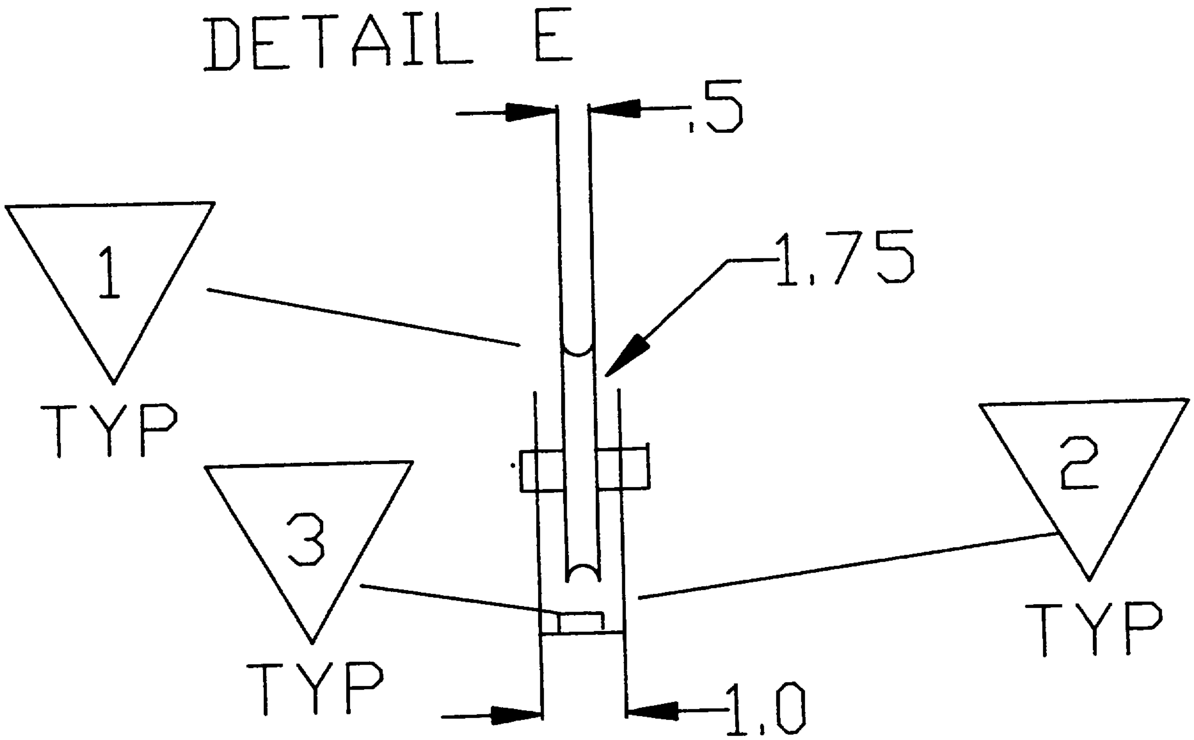
FOLDOUT FRAME 2

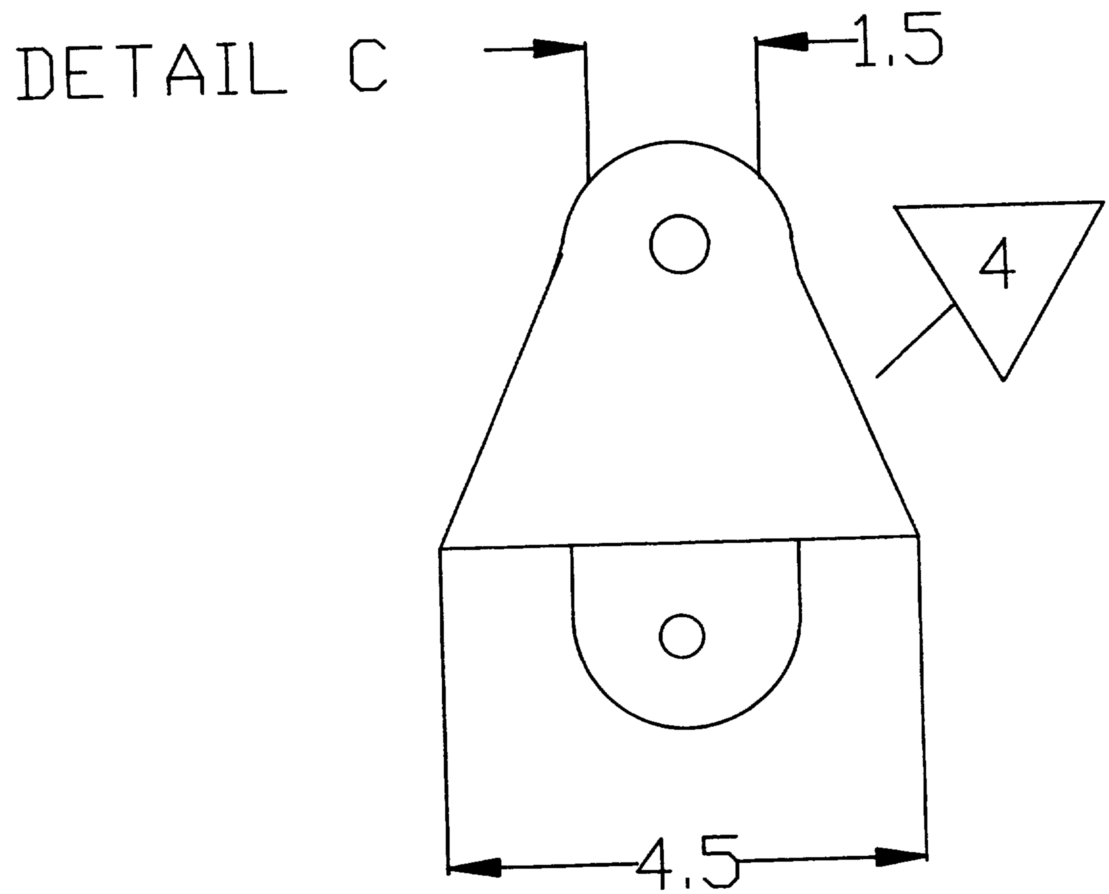



DETAIL A

| DATE | BY | DWG. NO. | SHT. |
|---|---|---|---|
| 4/29/94 | M. CLARK | S94-1A-401-1B | 4 of 5 |

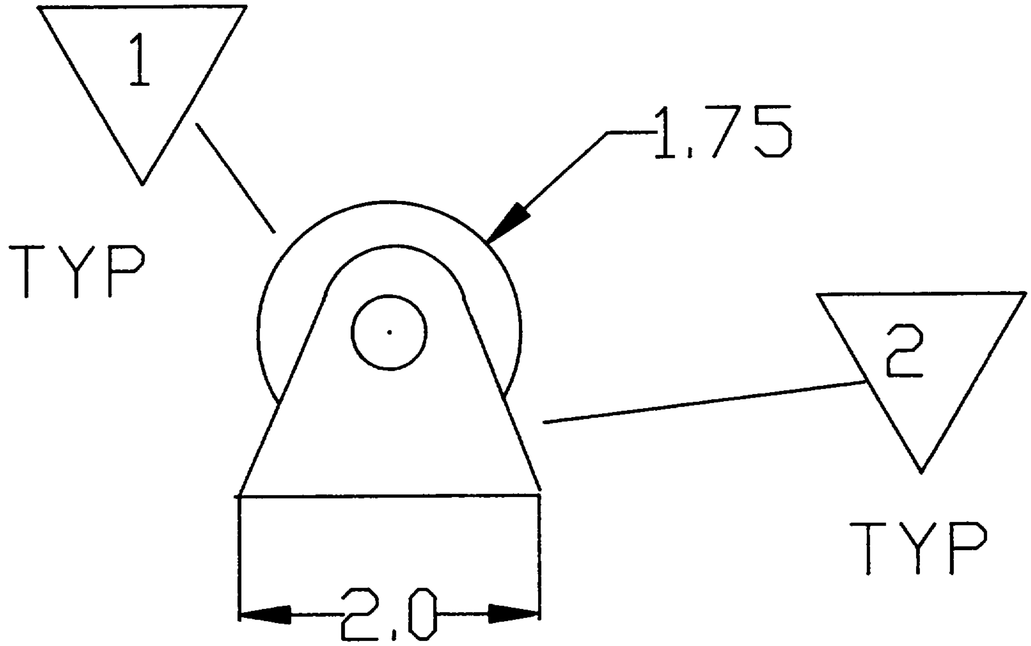
FOLDOUT FRAME /



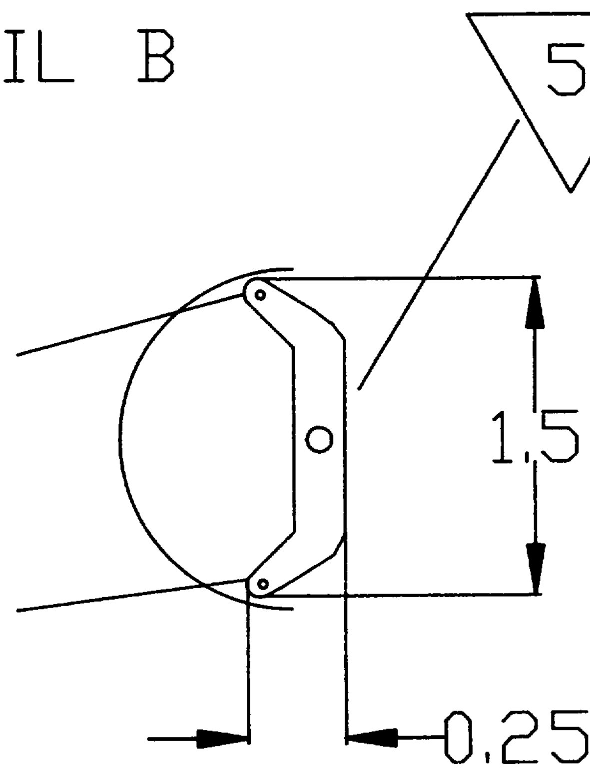



FOLDOUT FRAME 2

# DETAIL D

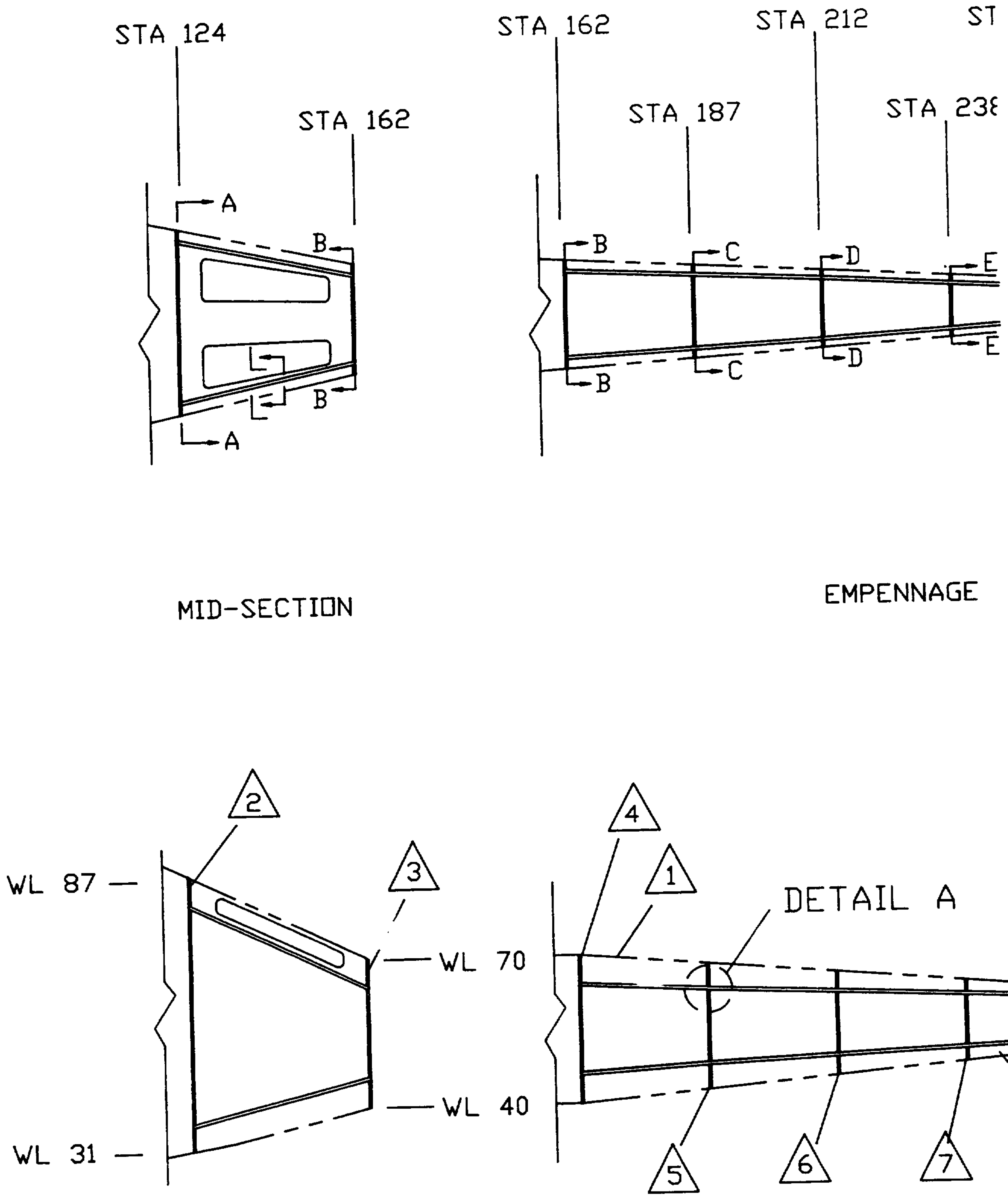



# DETAIL B




| DATE | BY | DWG. NO. | SHT. |
|---|---|---|---|
| 4/29/94 | M. CLARK | S94-1A-401-1B | 5 of 5 |

FOLDOUT FRAME




SCALE: 1=30

NOTE: SKIN APPEARS AS PHANTOM LINE

FOLDOUT FRAME 2


| ITEM | QTY. | DESCRIPTION | SIZE OR PART NUMB |
|---|---|---|---|
| 23 | 92 | RIVET, TYP. | MS20430DD-3-5 |
| 22 | 1 | NUT | AN315-D6 |
| 21 | 12 | ANGLE BRACKET (SIZE VARIES) | 2024-T3, 0.100", THK. |
| 20 | 50 | RIVET, TYP. | MS20430DD-3-4 |
| 19 | 1 | EYE BOLT | AN6 |
| 18 | 3 | DOUBLER (SIZE VARIES) | 2024-T3, 0.050", THK |
| 17 | 48 | NUT, TYP. | AN315-D4 |
| 16 | 48 | BOLT, TYP. | AN4DD4 |
| 15 | 122 | WASHER, TYP. | AN960-D816L |
| 14 | 61 | NUT, TYP. | AN365-D820 |
| 13 | 1966 | RIVET, TYP. | MS20430DD-2-3 |
| 12 | 61 | BOLT, TYP. | AN8DD6 |
| 11 | 11 | WASHER | AN960-D616 |
| 10 | 1 | TAIL INT. INSPECTION PANEL | 2024-T3, 0.020", THK |
| 9 | 1 | EMPENNAGE FORMER | 2024-T3, 0.020", THK |
| 8 | 1 | EMPENNAGE FOPMER | 2024-T3, 0.020", THK |
| 7 | 1 | EMPENNAGE FORMER | 2024-T3, 0.020", THK |
| 6 | 1 | EMPENNAGE FORMER | 2024-T3, 0.020", THK |
| 5 | 1 | EMPENNAGE FORMER | 2024-T3, 0.020", THK |
| 4 | 1 | EMPENNAGE FORMER | 2024-T3, 0.020", THK |
| 3 | 1 | MID-SECTION FORMER | 2024-T3, 0.020", THK |
| 2 | 1 | MID-SECTION FORMER | 2024-T3, 0.020", THK |
| 1 | 1 | SKIN | 2024-T3, 0.020", THK |

PARTS LIST

DIMENSION TOLERANCES UNLESS OTHERWISE SPECIFIED

DECIMAL

.XX ± .01
.XXX ± .001

ANGULAR

± 0.5°

EMBRY-RIDDLE AERONAUTICAL UNIVERSITY
DAYTONA BEACH, FL

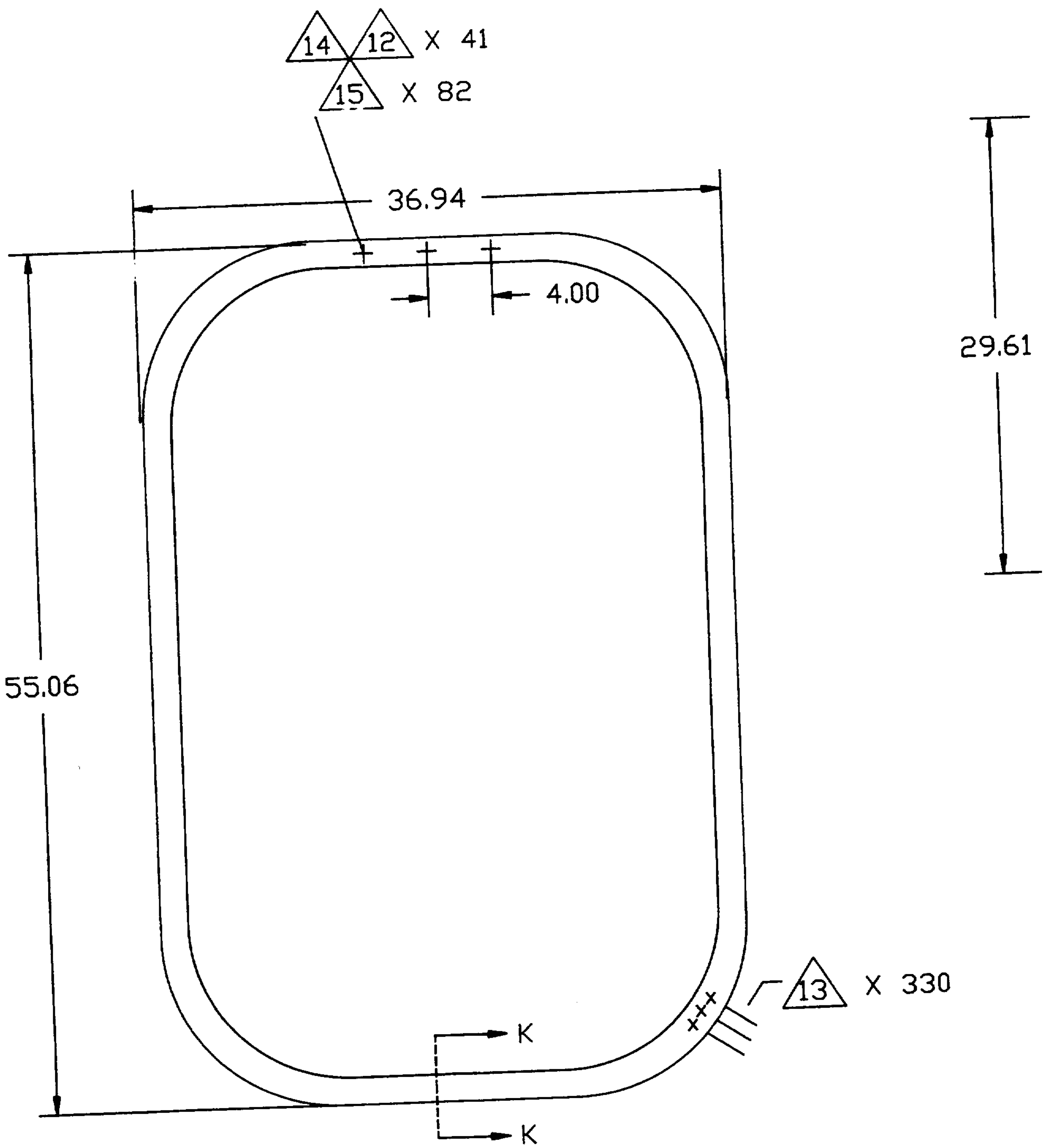
| SIZE | DATE | SCALE | DRAWN BY |
|---|---|---|---|
| B | 4/18/94 | VARIES | J. NEHER |

TITLE MID-SECTION AND EMPENNAGE

DRAWING NO. S94-1A-301-1B

SHEET 1 OF

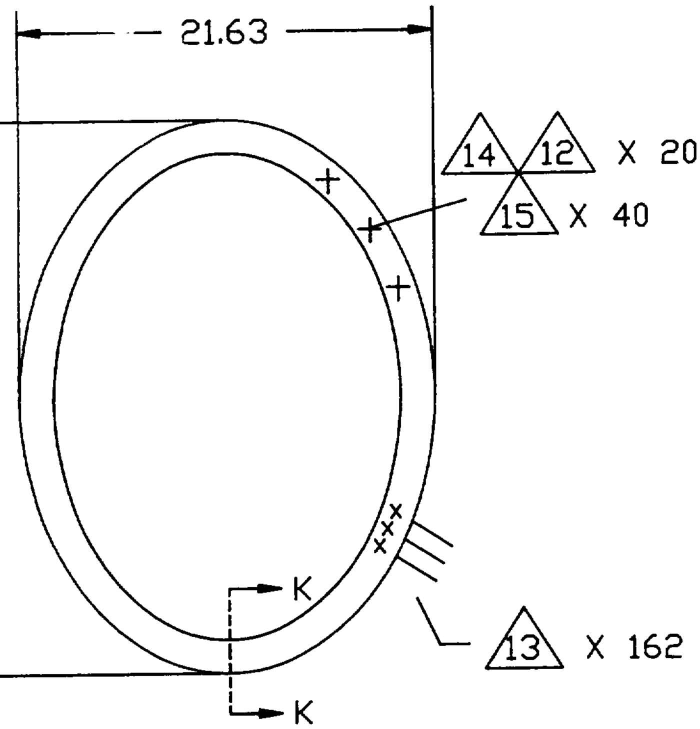
FOLDOUT FRAME



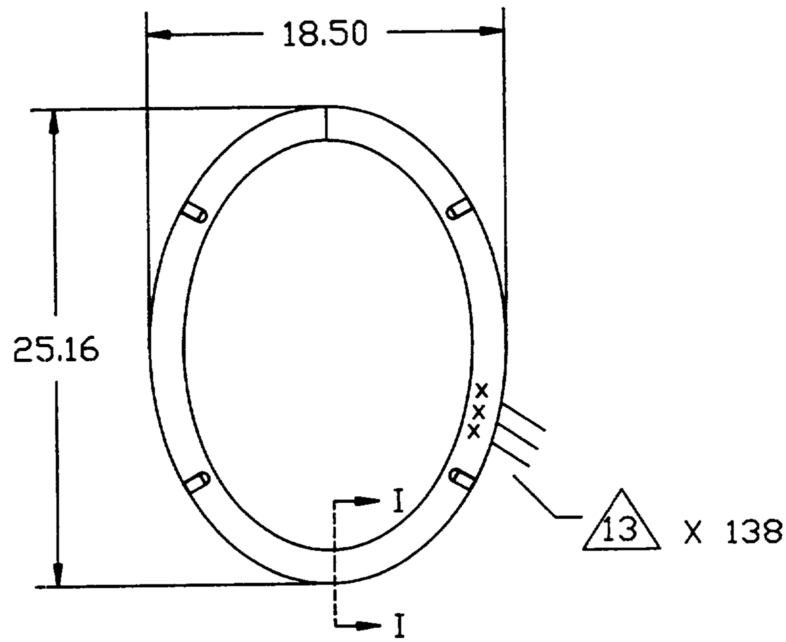

SECTION A-A
STA 124
MID-SECTION INTERFACE

SCALE: 1=10

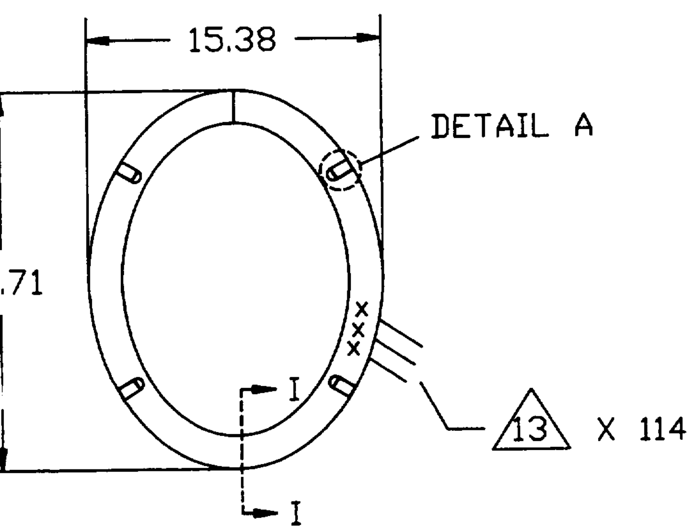
NOTE: ALL FORMERS 0.0
ALL 13 ARE 0.



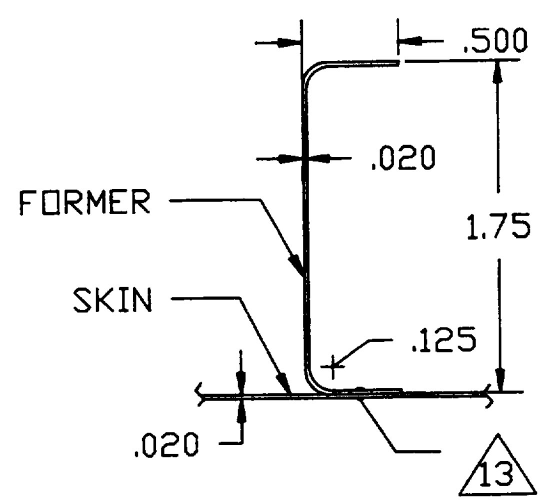

SECTION B-B
STA 162
EMPENNAGE INTERFACE




SECTION C-C
STA 187




SECTION D-D
STA 212

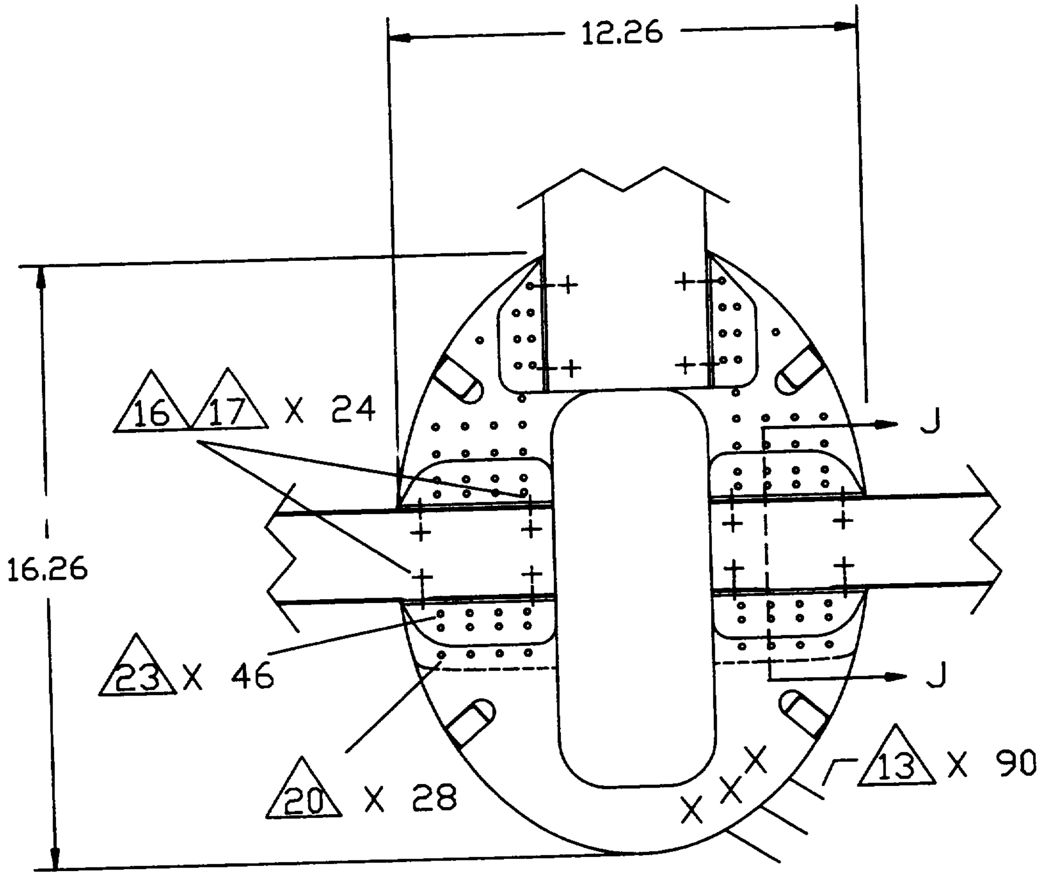



SECTION I-I

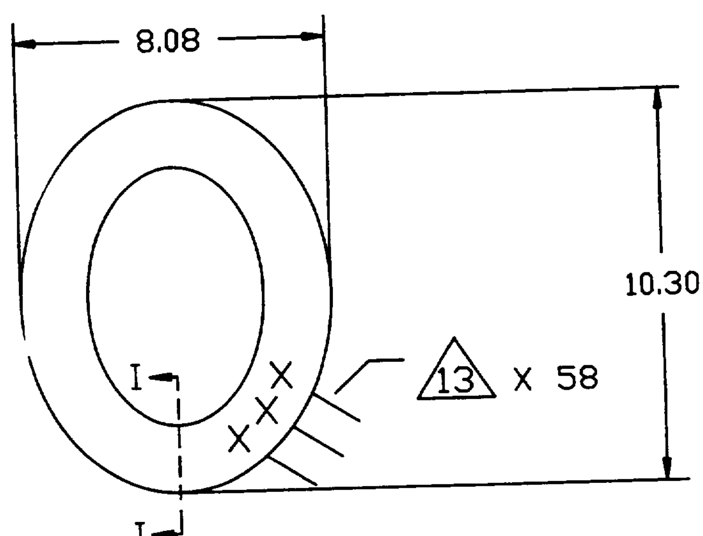
" 2024-T3
" APART

| DATE | BY | DWG. NO. | SHT. |
|---|---|---|---|
| 4/18/94 | J. NEHER | S94-1A-301-1B | 2 OF |

FOLDOUT FRAME



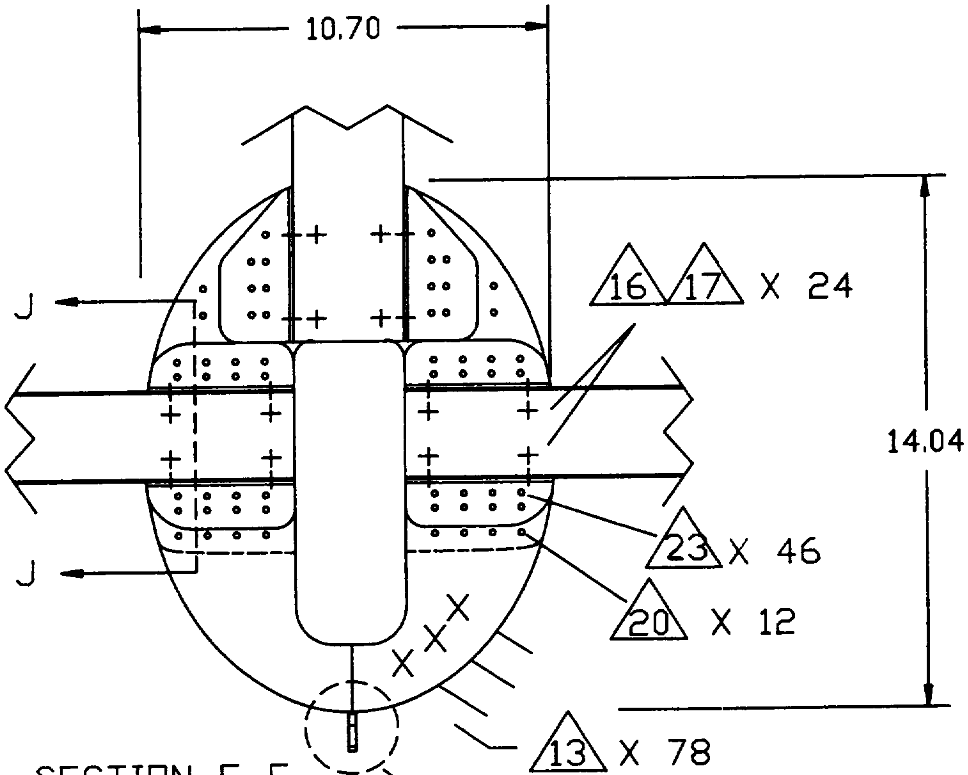

SECTION E-E
FORWARD TAIL INTERFACE
STA 238



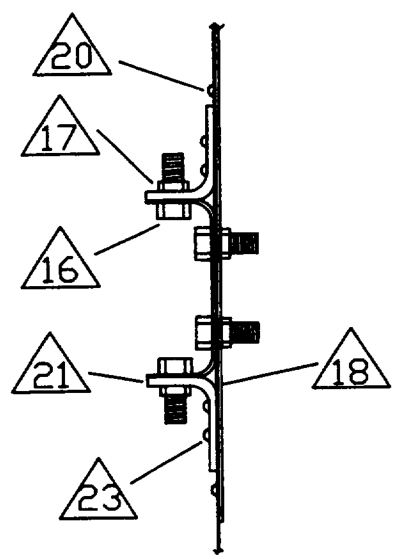

SECTION G-G
STA 271
(SEE NOTE B)

SC

NOTE B: ALL FORMER




SECTION F-F
REAR TAIL INTERFACE
STA 250



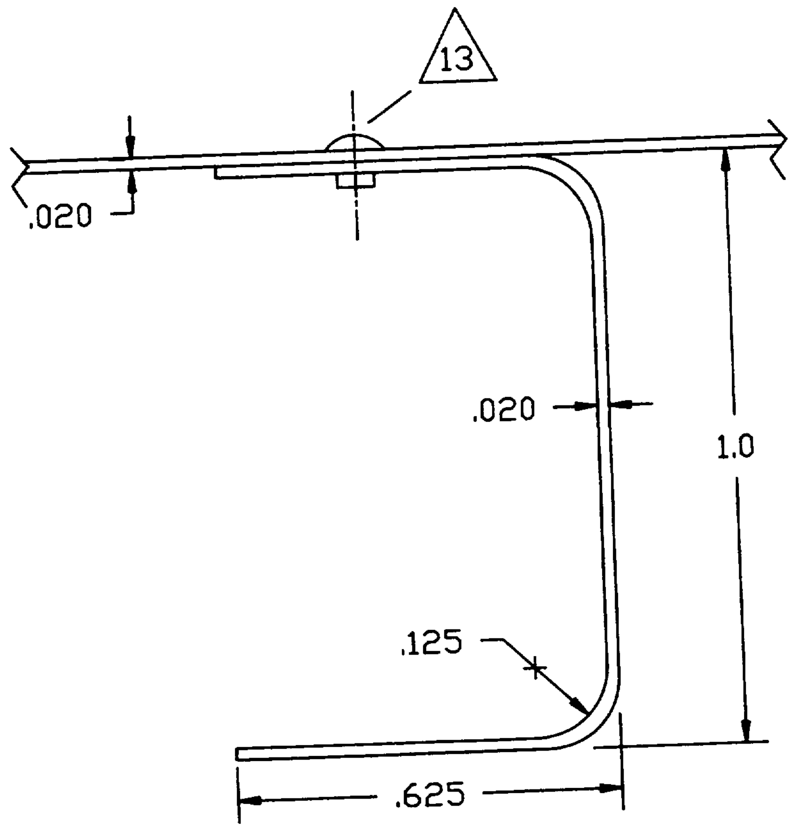

SECTION J-J

SCALE: 1=2

E: 1=5

. TYP. X-SEC.

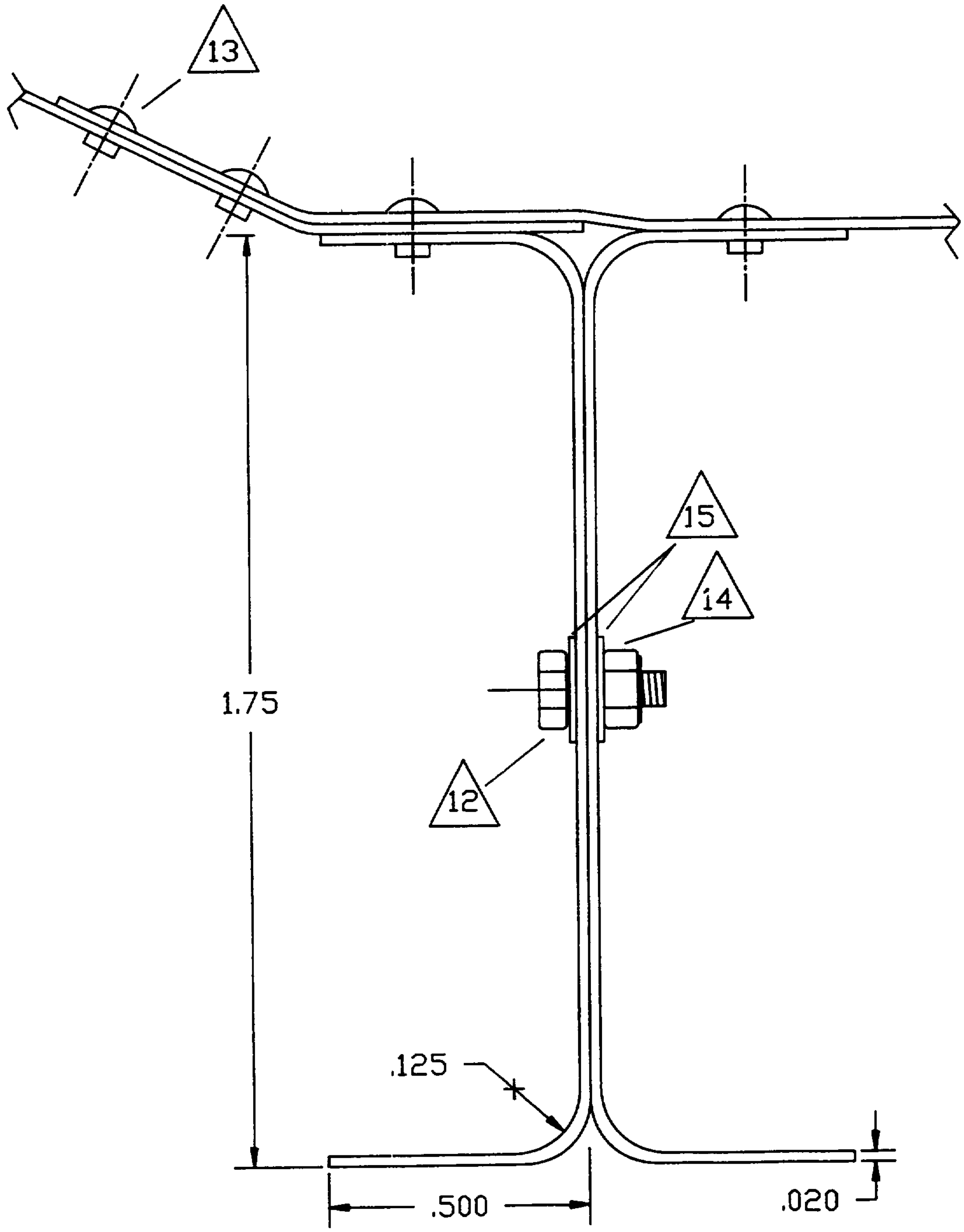
| DATE | BY | DWG. NO. | SHT. |
|---|---|---|---|
| 4/18/94 | J. NEHER | S94-1A-301-1B | 3 OF 5 |




DETAIL A
ROTATED 31 DEG. CLOCKWISE

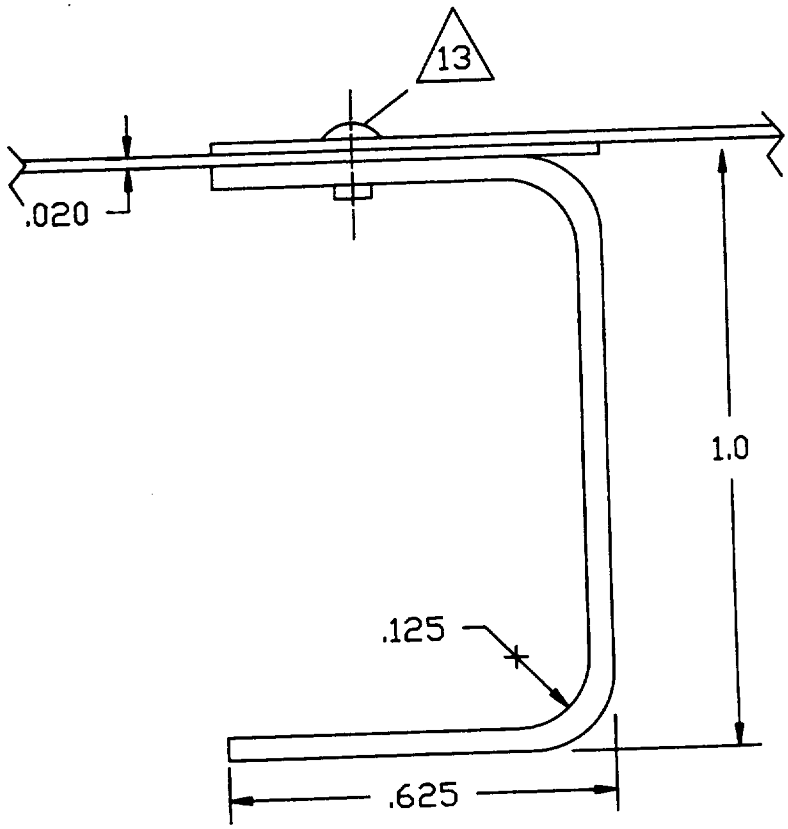
CHANNEL-FORMED STRINGER
EMPENNAGE

SCALE: 1



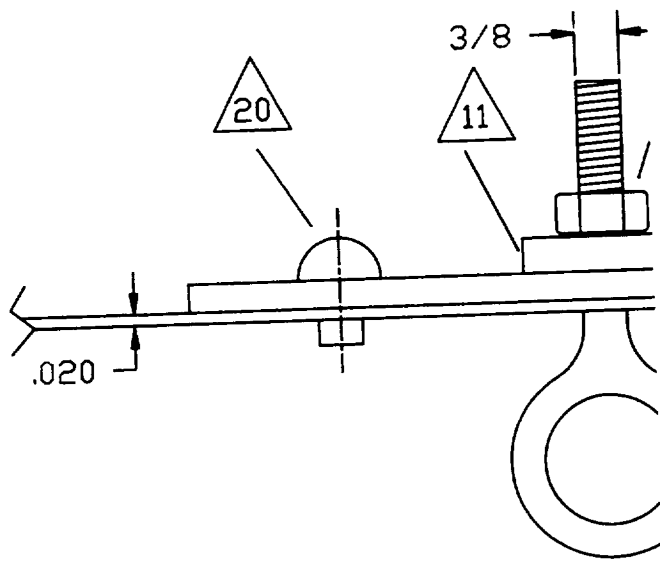

SECTION K-K
MID-SECTION AND
EMPENNAGE INTERFACE
(GEOMETRY VARIES)

| DATE | BY | DWG. NO. | SHT. |
|---|---|---|---|
| 4/18/94 | J. NEHER | S94-1A-301-1B | 4 OF |



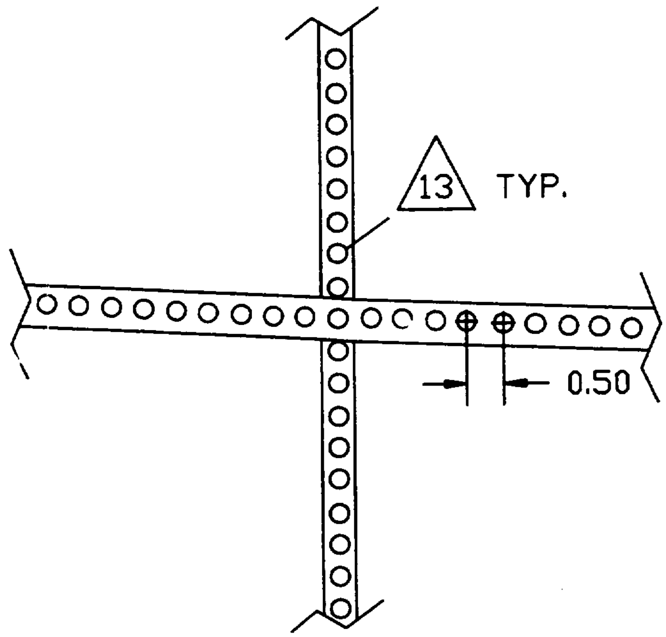

SECTION L-L
ROTATED 90 DEG. CLOCKWISE

CHANNEL-FORMED STRINGER
MID-SECTION



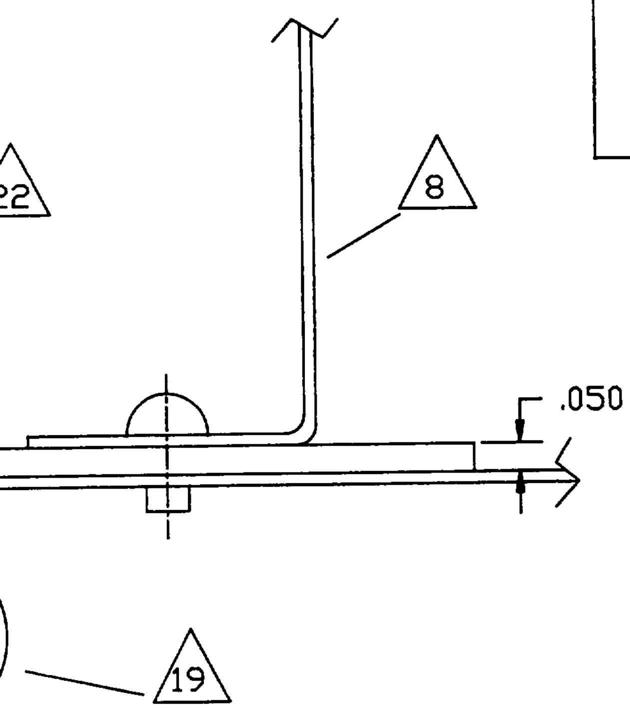

DETA
TIE-DOW

SCALE: 1=10




VIEW H-H
SKIN RIVITING
TYP. THROUGHOUT

SACLE: 1=4




B
BOLT

| DATE | BY | DWG. NO. | SHT. |
|---|---|---|---|
| 4/20/94 | J. NEHER | S94-1A-301-1B | 5 OF |

[redacted]

| | | | |
|---|---|---|---|
| 6 | 4 | SEAT TRACK | —————— |
| 5 | 1376 | RIVET | TYPE AD-AN430-DD-4-6 |
| 4 | 3650 | RIVET | TYPE AD-AN430-DD-3-4 |
| 3 | 20 | INVESTMENT CASTED JOINTS | 2224-T3<br>t=0.063 |
| 2 | 4 | SQUARE TUBE BEAM | 2224-T3<br>t=0.063<br>2.2 X 2.2 SQARE |
| 1 | 27 | HAT SHAPED BEAM | 2224-T3<br>t=0.063 2.0X2.5<br>0.75 FLANGES |
| ITEM | QTY | DESCRIPTION | MATERIAL OR PART # |

DIMENSION TOLERANCES UNLESS OTHERWISE SPECIFIED

DECIMAL

.XX ± .01
.XXX ± .001

ANGULAR

± 0.5°

EMBRY-RIDDLE AERONAUTICAL UNIVERSITY
DAYTONA BEACH, FL

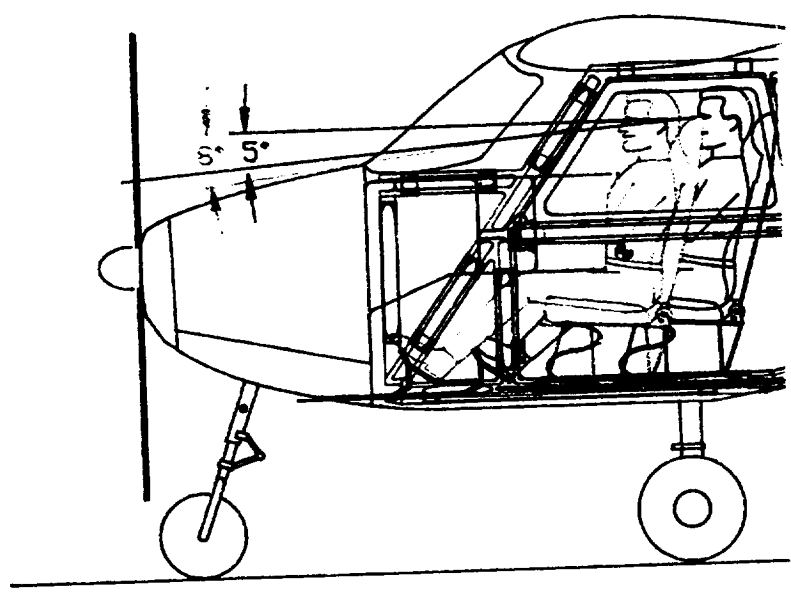
| SIZE | DATE | SCALE | DRAWN BY |
|---|---|---|---|
| B | 4/22/94 | VARIABLE | A MEISS |

TITLE CAGE LAYOUT FOR TRITON

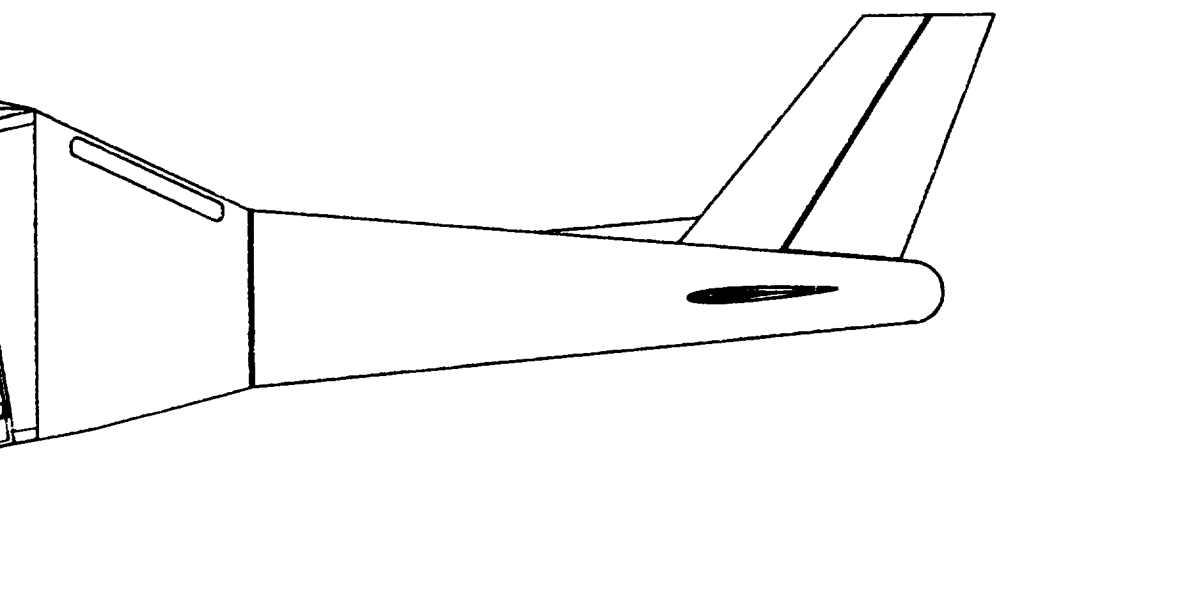
DRAWING NO. S94-1A-201-1B

SHEET 1 of 9

FOLDOUT FRAME 1



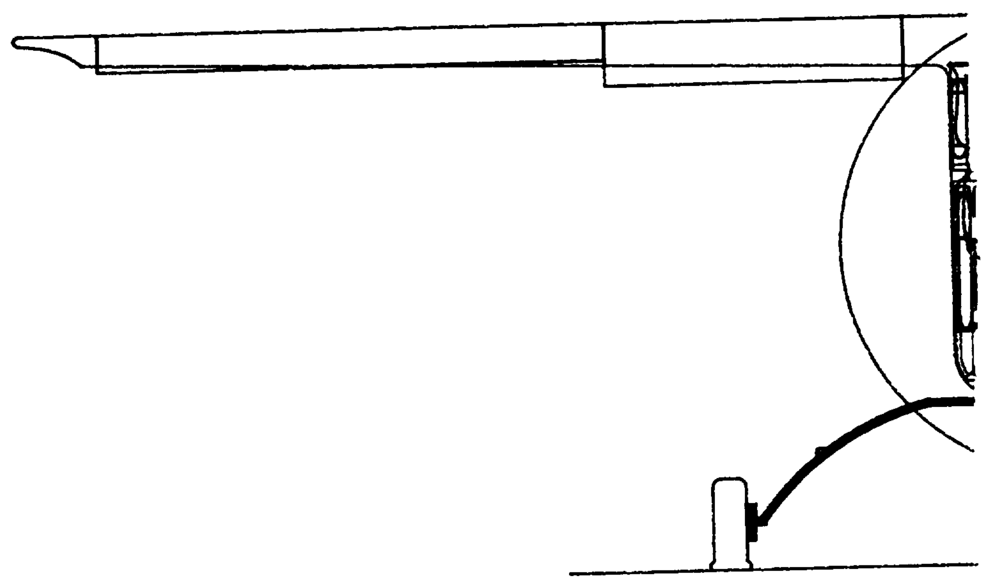

SCALE:



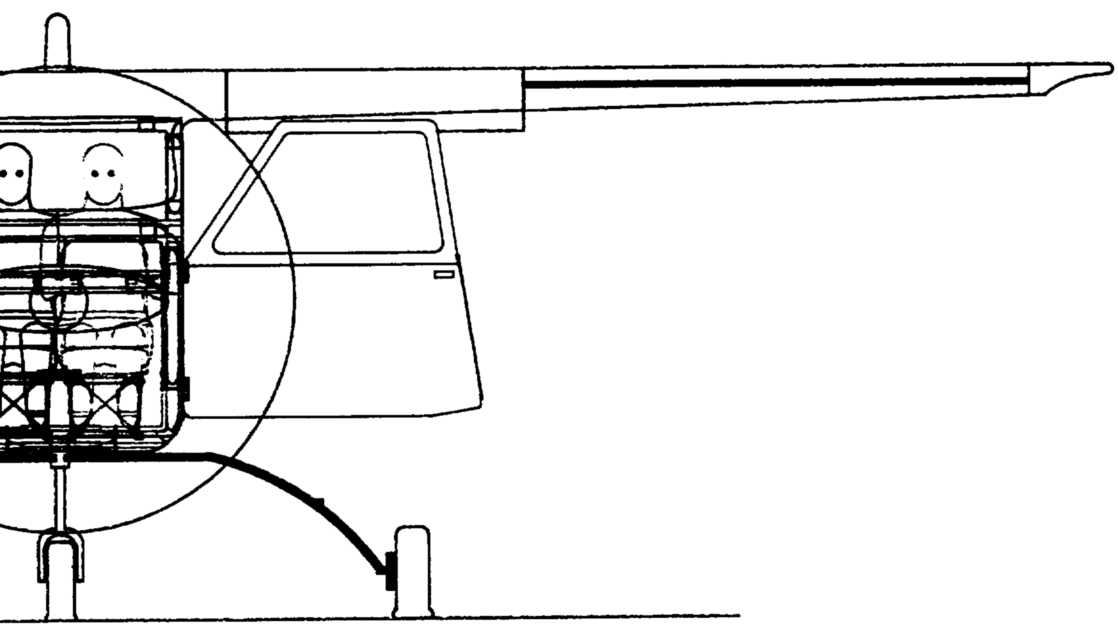
:30

| DATE | BY | DWG. NO. | SHT. |
|---|---|---|---|
| 4/22/94 | A MEISS | S94-1A-201-1B | 2 of 9 |

FOLDOUT FRAME 1.



SCALE

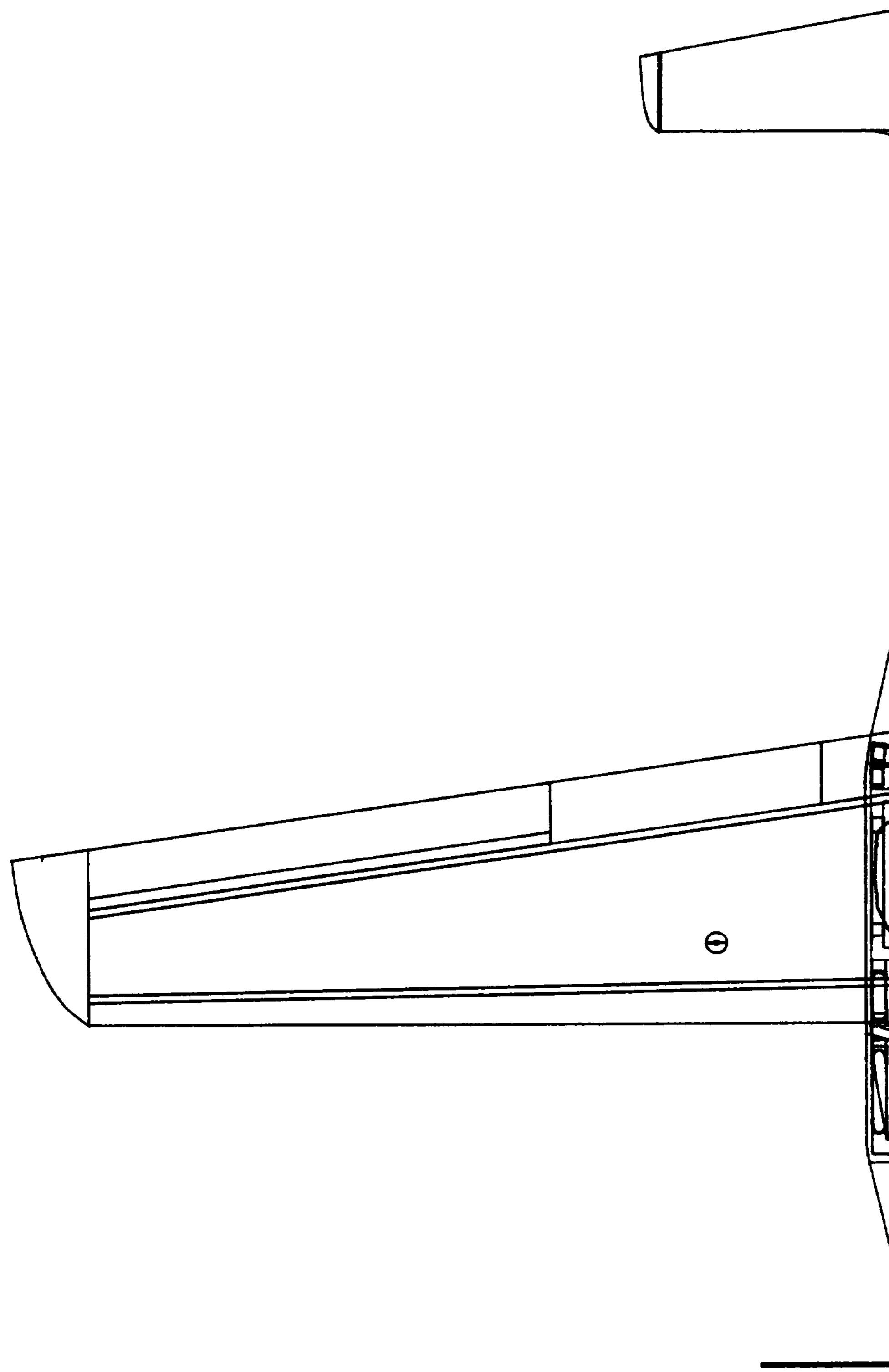


1=30

| DATE | BY | DWG. NO. | SHT. |
|---|---|---|---|
| 4/22/94 | A MEISS | S94-1A-201-1B | 3 of 9 |

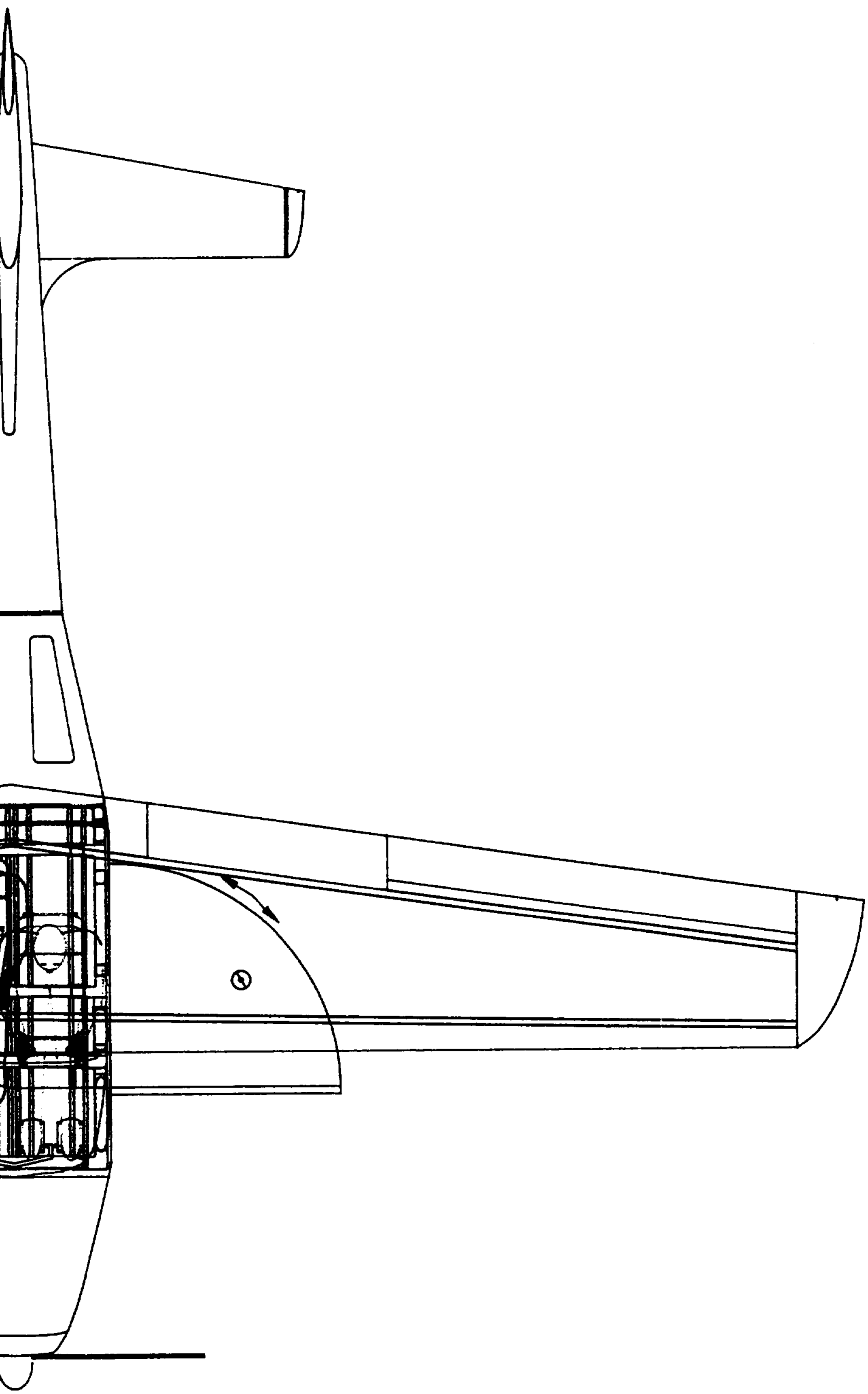
FOLDOUT FRAME

1.

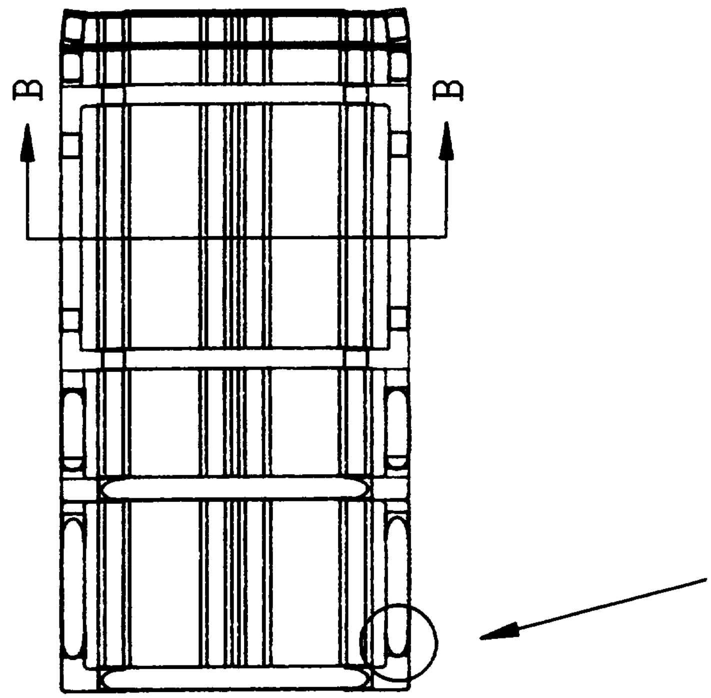


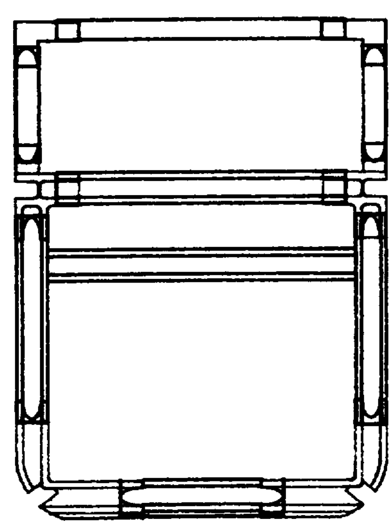
SCALE: 1=30

FOLDOUT 2.

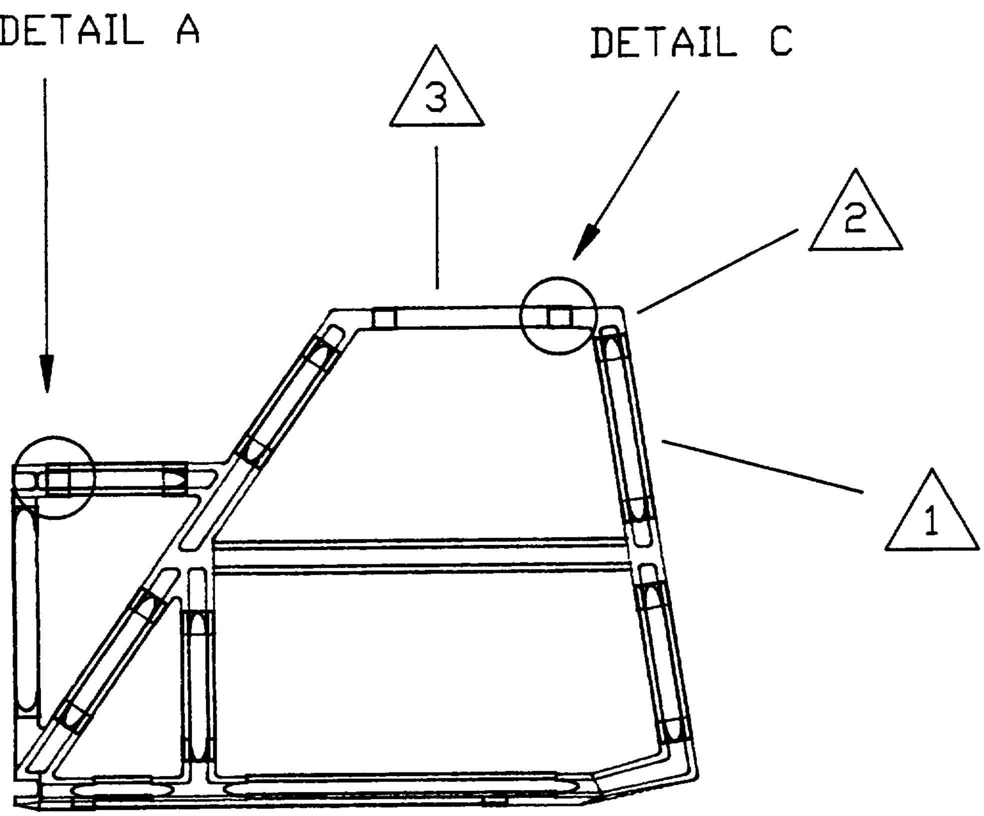


| DATE | BY | DWG. NO. | SHT. |
|---|---|---|---|
| 4/22/94 | A MEISS | S94-1A-201-1B | 4 of 9 |



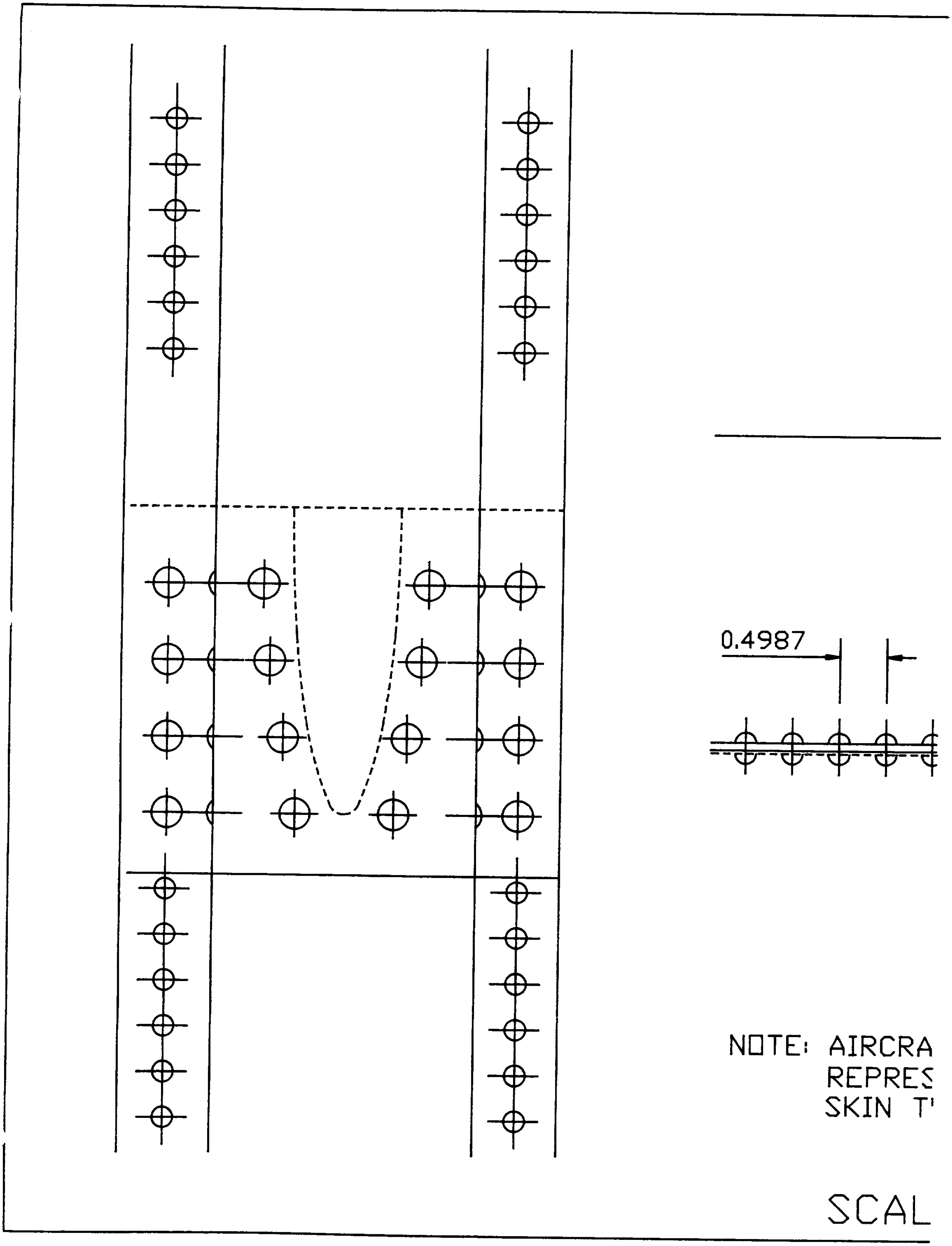



SCALE: 1



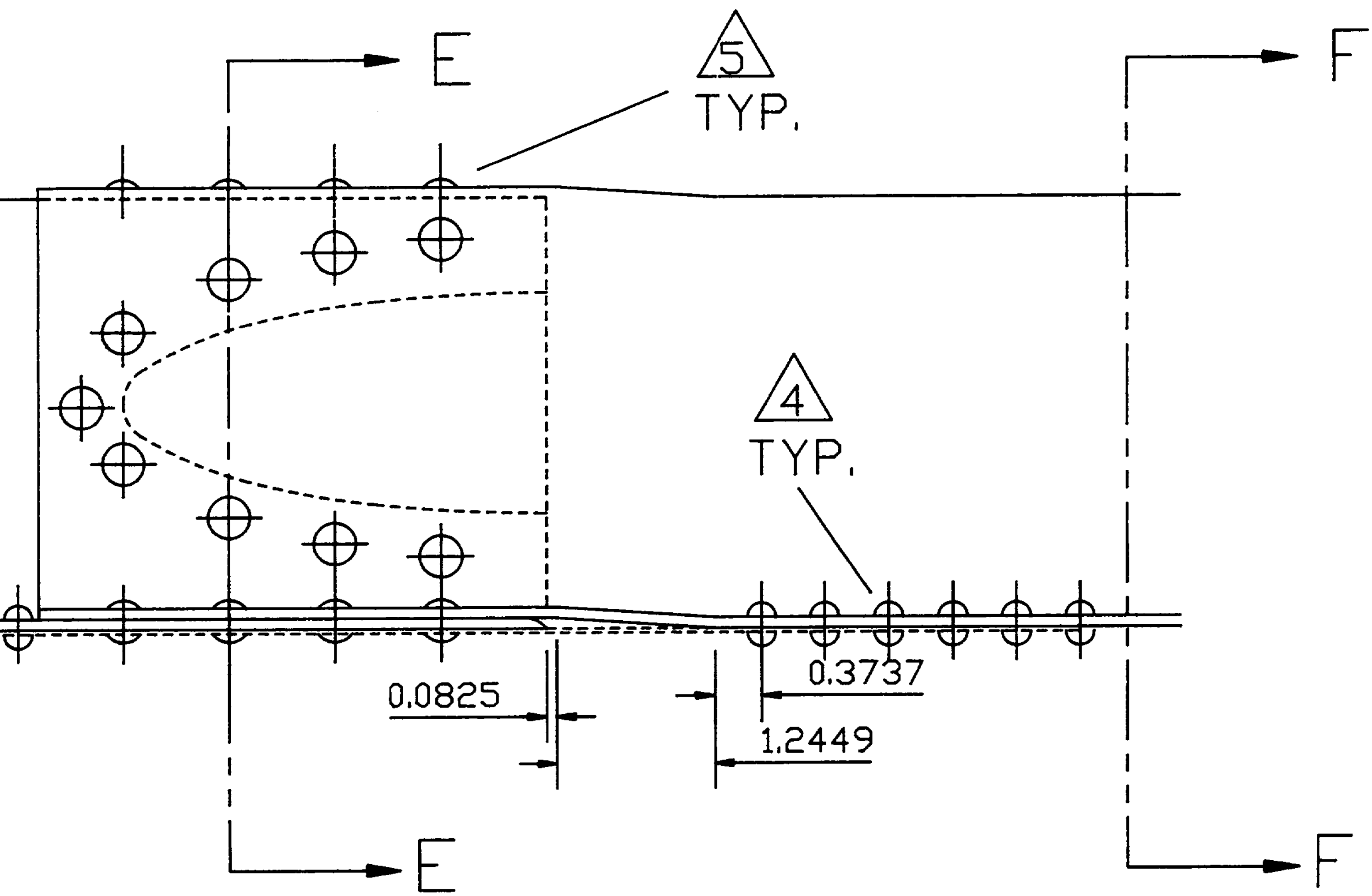

20

| DATE | BY | DWG. NO. | SHT. |
|---|---|---|---|
| 4/22/94 | A. MEISS | S94-1A-201-1B | 5 of 9 |


0.4987
NOTE: AIRCRA
REPRES
SKIN T'
SCAL

2

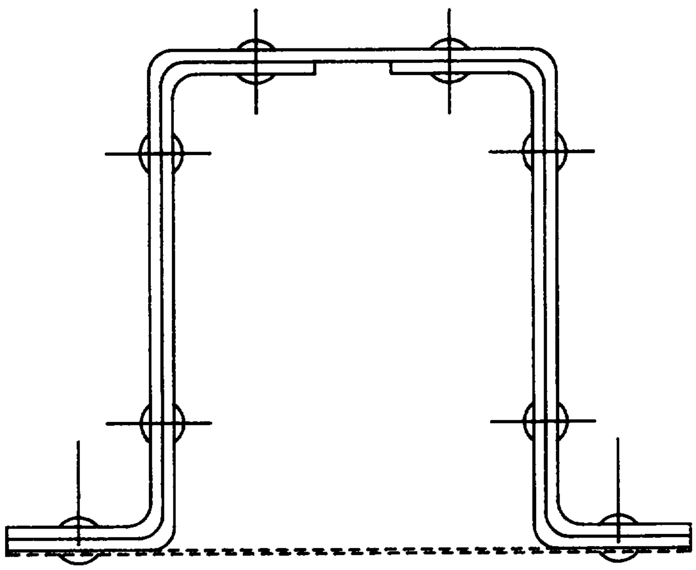
# VIEW "A"




T SKIN IS
NTED BY HIDDEN LINE
CKNESS IS 0.020 IN

| | | | | |
|---|---|---|---|---|
| : 1=1 | DATE 4/22/94 | BY A. MEISS | DWG. NO. S94-1A-201-1B | SHT. 6 of 9 |

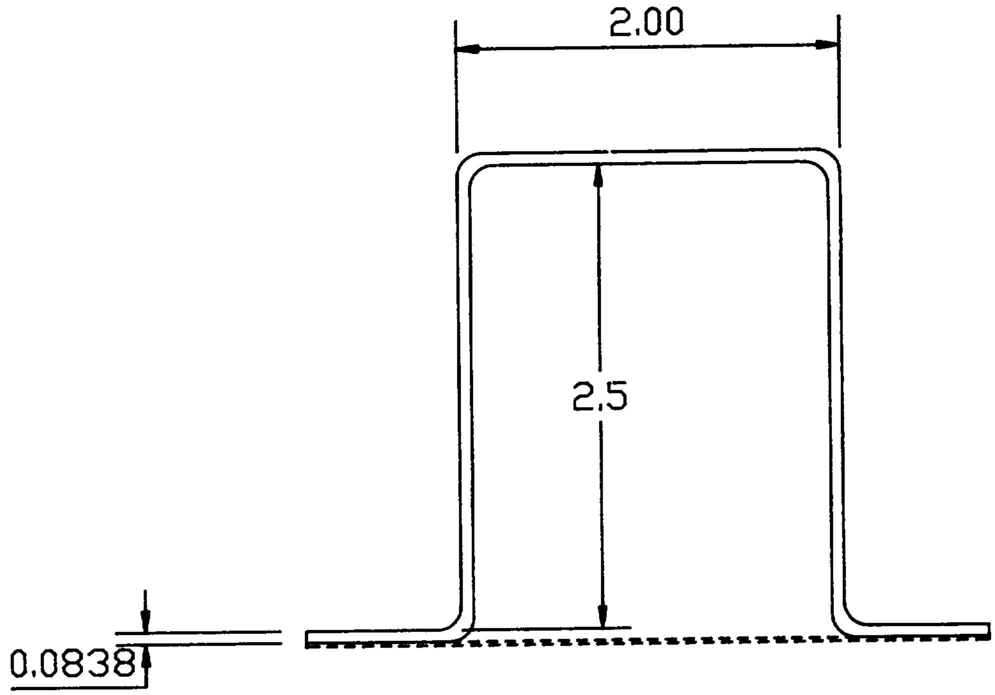
FOLDOUT FRAME 1



VIEW "E-E"

NOTE: AIRCRAFT SKIN IS
REPRESENTED BY HIDDEN LINE
SKIN THICKNESS IS 0.020 IN

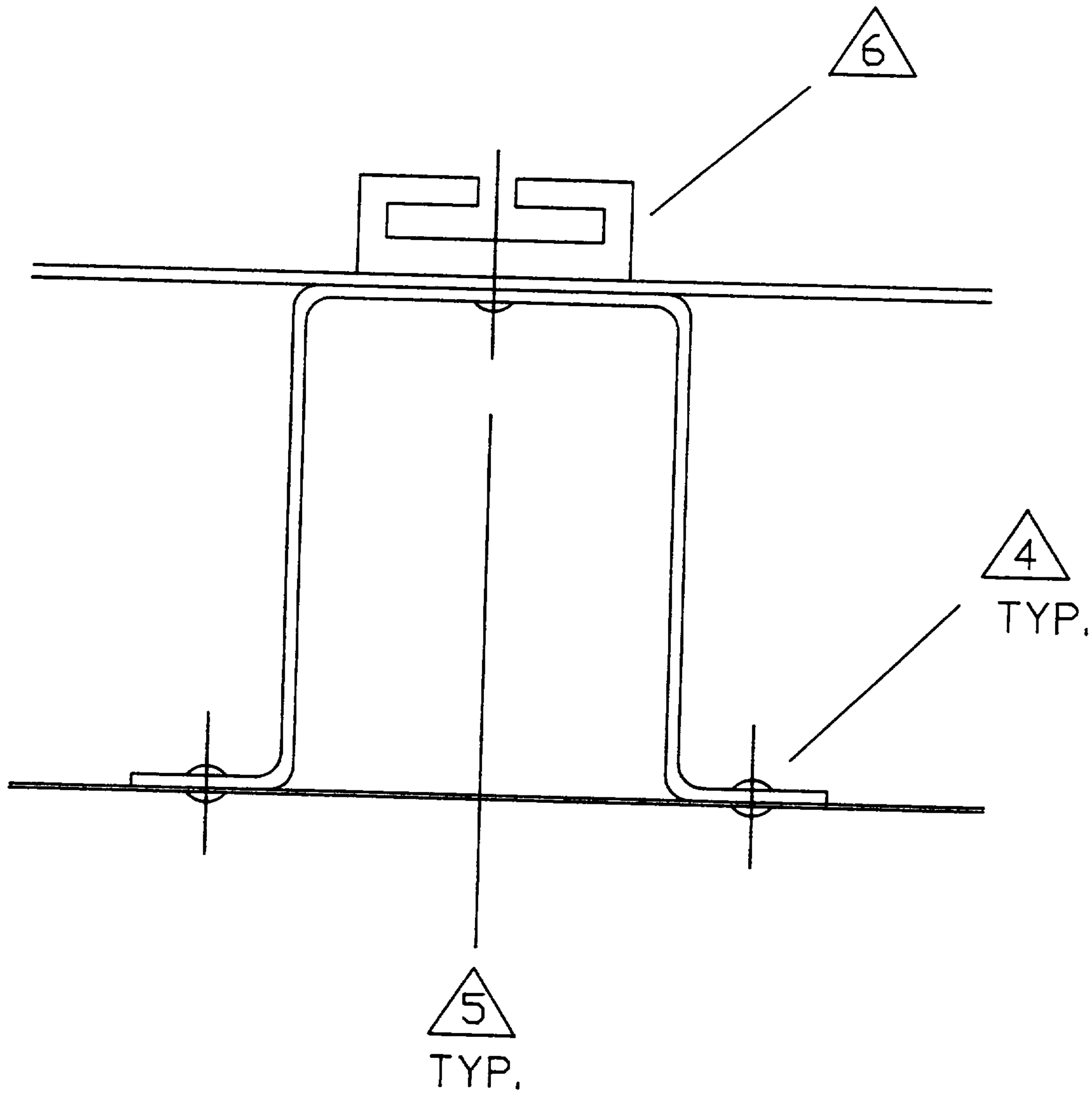
SCALE: 1=1




VIEW "F-F"

| DATE | BY | DWG. NO. | SHT. |
|---|---|---|---|
| 4/22/94 | A. MEISS | S94-1A-201-1B | 7 of 9 |

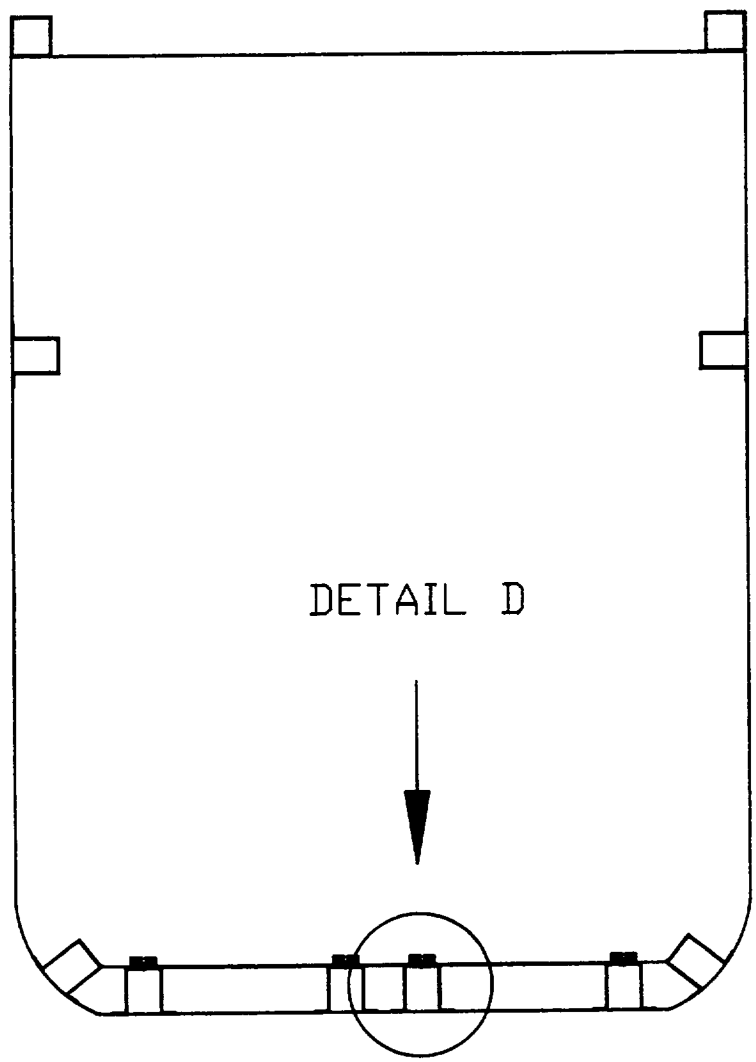
FOLDOUT FRAME 1.




DETAIL D

SCALE: 10=1

SCALE:

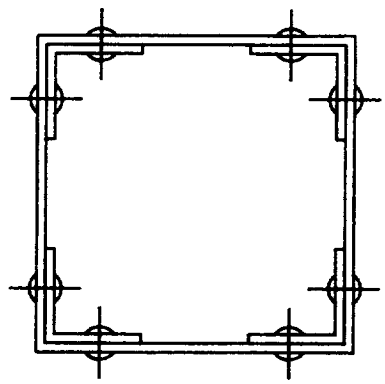



SECTION B-B

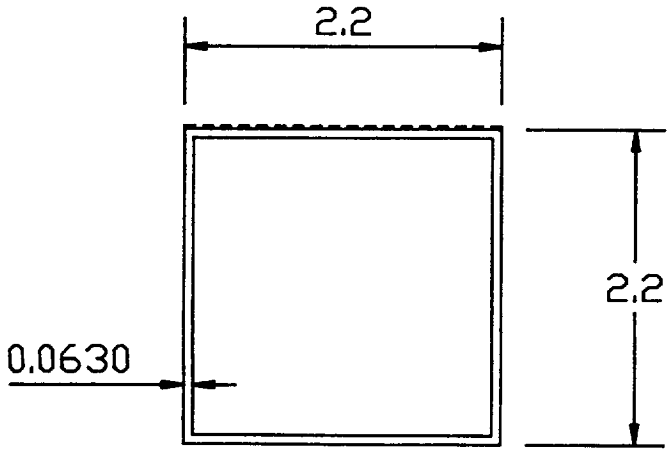
1=10

| DATE | BY | DWG. NO. | SHT. |
|---|---|---|---|
| 4/22/94 | A. MEISS | S94-1A-201-1B | 8 of 9 |

/.



VIEW "G-G"

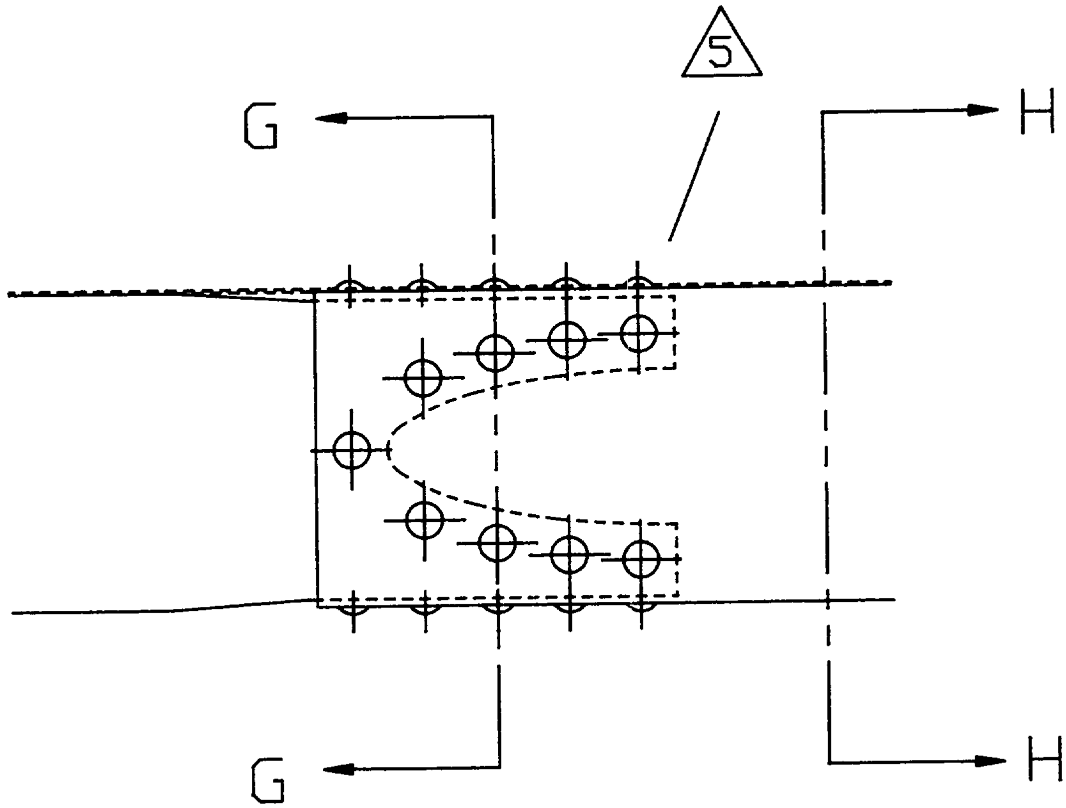



VIEW "H-H"

NOTE: AIR
REF
SKI

SCALE:

C-2




VIEW "C"

RAFT SKIN IS
RESENTED BY HIDDEN LINE
THICKNESS IS 0.020 IN

=1

| DATE | BY | DWG. NO. | SHT. |
|---|---|---|---|
| 4/22/94 | A. MEISS | S94-1A-201-1B | 9 of 9 |